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POWER

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INSTRUMENTS & CONTROL
PIPING SYSTEMS
MECHANICAL TRANSMISSION
POWER MISCELLANY

JUNE, 1938

Highlights on Millers Ford Station, Dayton Pwr. & Lt..... 50
Tested power-accounting system at Diamond Crystal Salt... 54
Portable fire protection at Empire State Building..... 57
When the boss says no new plant—try small improvements.. 58
Largest comfort-cooling plant to condition Congress..... 60
Clean electrical equipment is breakdown insurance..... 63
Superheat may mean savings for small steam plants..... 64
How and why of power pumping—Special Section No. 19.. 65
- What is head on a pump?..... 66
- How rotary pumps operate..... 69
- Centrifugal pumps—types and applications..... 70
- Reciprocating pumps—simplex, duplex, triplex..... 72
- Selecting and using deepwell pumps..... 74
- Factors to consider in pump operation..... 75
- Boiler-feed pumps—types and applications..... 76
- Methods and equipment for priming pumps..... 78
- How to select drives for various pumps..... 80

Oil and gas power—installations and useful data..... 81
Photostory—Chevrolet boiler plant at Tonawanda, N. Y.... 89
Data Sheet No. 70—types of chain and accessories..... 92

DEPARTMENTS

Exhaust Lines..... 59
Engineers' Books..... 94
Practical Aids..... 98
Readers' Problems..... 110
Current Comment..... 93
News, Straws..... 95
New Plant Equipment.... 104
George Edwards..... 116

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FULL POWER *from*

Get full value from every pound of coal you burn. Continuous, wave-like motion of the Link-Grate section acts upon the fuel bed to assure thorough and efficient combustion.

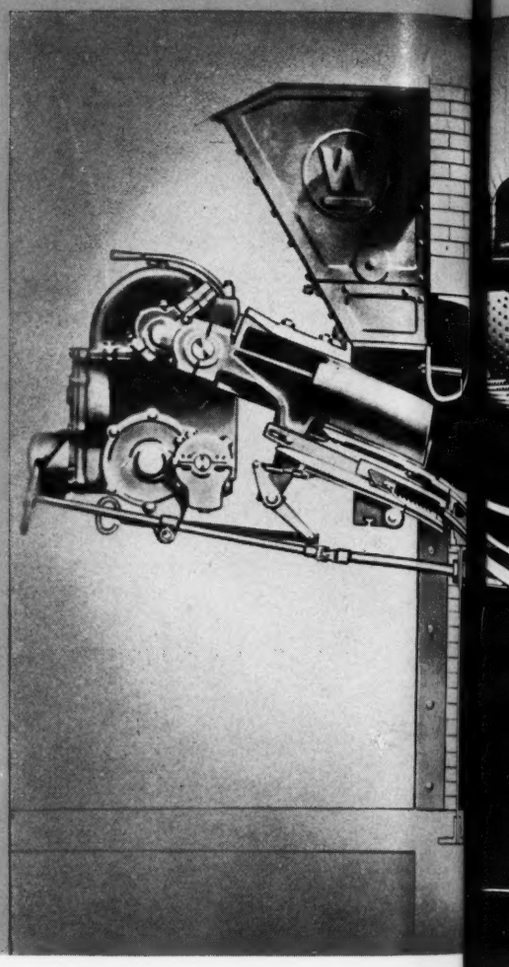
The successful results secured by users of the Link-Grate Stoker in its many installations, demonstrate its effectiveness in getting full power from every pound of coal.

For example, the operating log of a plant* in New York State records a combined boiler and stoker efficiency of 82%. The boiler is equipped with a Link-Grate Stoker but no economizer or air preheater.

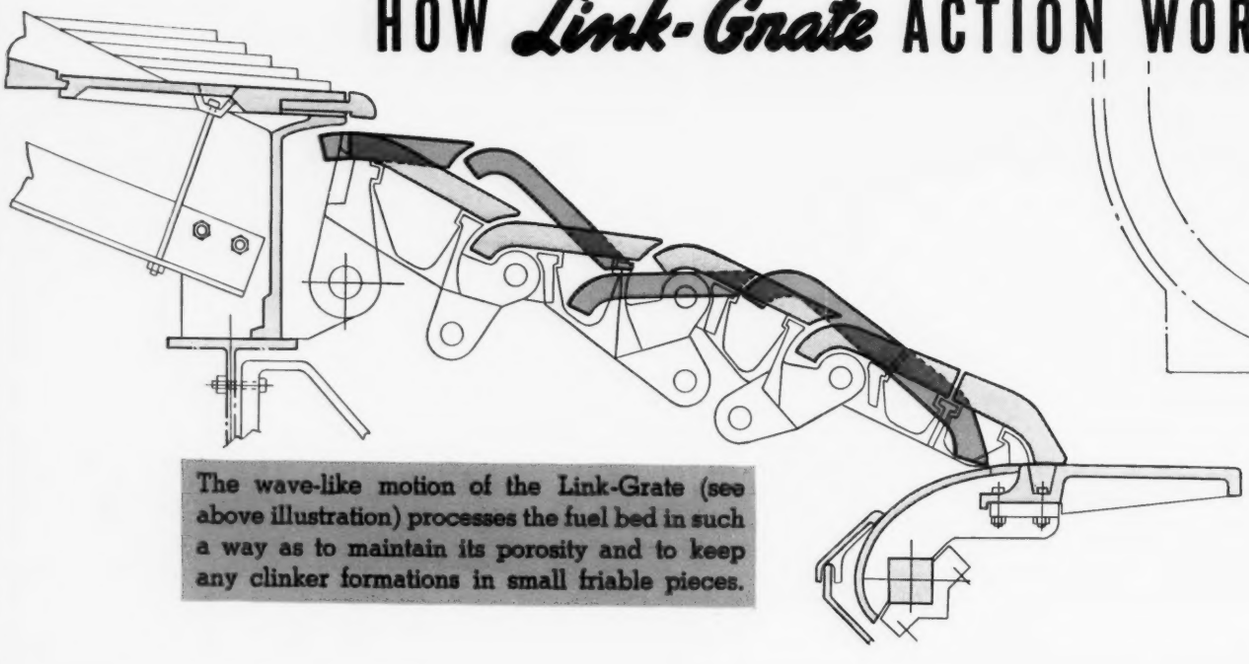
* * *

Qualified Combustion Engineers located in principal Westinghouse District Offices will be pleased to give you full information. J-50161

**Name of plant furnished upon request.*



HOW *Link-Grate* ACTION WORKS



The wave-like motion of the Link-Grate (see above illustration) processes the fuel bed in such a way as to maintain its porosity and to keep any clinker formations in small friable pieces.

every pound of coal

..because this

Link-Grate Action

assures thorough combustion!

DEPENDABILITY
FLEXIBILITY
HIGH EFFICIENCY
SAFETY
LOW MAINTENANCE

Westinghouse Stokers

Essential Factors in Low-Cost Steam Generation

OLSON'S CHIEF ENGINEER specifies WROUGHT IRON Because He Won't Stand For Corrosion

● "We have some delicate processes here in the coloring of rugs," says the Chief Engineer of the Olson Rug & Carpet Company plant, Chicago, Illinois. "So we can't afford to take a chance on corrosion. Some of our pipe is buried and not to come out again, so that is another reason wrought iron is specified."

In the Olson Rug plant, one of the most modern in the country, wrought iron is used for all hot and cold water lines; heat reclaimers; stoker bearing coolers; lines leading to de-superheaters; and all process lines.

When selecting material for any corrosive service, consider the long performance record of Byers Wrought Iron, in all lines of industry, in resisting corrosion. Wrought iron avoids premature failures, frequent repairs and unnecessary shut-downs.

Let us assist you in analyzing the corrosive conditions in your plant. Also send for our new technical bulletin "Wrought Iron for Piping Systems." Get in touch with our nearest Division Office or write our Engineering Service Department in Pittsburgh. A. M. Byers Company. Established 1864. Pittsburgh, Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston, Seattle, San Francisco.

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TUBULAR AND FLAT ROLLED PRODUCTS

SPECIFY BYERS GENUINE WROUGHT IRON PIPE FOR CORROSIVE SERVICES AND BYERS STEEL PIPE FOR YOUR OTHER REQUIREMENTS

POWER

Established 1882 PHILIP W SWAIN, Editor

Man vs Power

WORKING with nature, man created a mechanical world in his own magnified image. Fuel became his food, engines his muscles, production machines his hands, mechanical transportation his legs. His eyes were amplified by lenses and photography, his ears by electrical communication. Made bold by these successes, he sought machines with brains and memory, and found them in mechanical devices for measuring, recording, accounting, computing, controlling.

Man has made wonderful machines. Will powered machines unmake man? Opinions differ. One writer paints a picture of infinite felicity, all machine made. The next—revolting against the noise, dirt, disorder and monotony so often associated with machines—pronounces mechanics a curse which the human race would be well rid of. Both views are irrational, but the first comes closer to the truth, as I said in my recent talk at the Midwest Power Conference. Many of the publicized benefits of the machine age are actual accomplishments. Every evil of the machine age can be cured without sacrificing the machine itself. On the other hand, any attempt to restore an imagined Arcadia by returning to primitive methods of agriculture, transportation and manufacturing would create nothing but utter chaos.

It is the true artist, above all, who revolts at the bad features of the present machine age, yet some of today's greatest creative spirits in the fields of music, architecture and the graphic arts have long ceased damning the machine. Instead, they work with it to create new beauties. When a Walt Disney does that, the result is a Snow White—a mere sample of things to come from unions of this sort.

Before the machine, most men were slaves to nature or other men. Today, man is to some degree enslaved by the machine, but much less so than is popularly supposed. Short hours make monotony far more bearable. More important, monotony itself is rapidly being abolished.

By its very nature, the machine is fitted not only to exert heavy forces, but to perform the most delicate and intricate operations, provided only that they are monotonous. Thus the machine likes what man does not like, and the two are as perfectly fitted for life partnership as Jack Sprat and his wife.

Today thousands of machines move their own levers and push their own buttons, read dials, judge color, make records, carry out elaborate fixed or conditional instructions. Modern controls have eyes, ears and memories. The ultimate end of all this, if man permits, is to leave nothing for man to do but the interesting jobs—those requiring versatility, broad mechanical skill, imagination, judgment, human understanding and salesmanship.

The capabilities of power and machines include many of the things the world is seeking, such as the elimination of poverty, more leisure, a broader and richer life for all. These potential benefits will become real whenever man, by greater mastery of the supreme art of getting along together, says the word.

Yet, if past experience is any guide, he will not get most of them very quickly. So far he has profited greatly by his use of power and machines, but not at all in proportion to the horsepower hours used or the output of his mass-production equipment. The reason, of course, is mutual cancellation of benefits, partly from the law of diminishing returns, yet largely as a direct result of human stupidity and folly. Expanding power and machines give man margin, which he can use as he wishes—for real benefits or for mutual cancellation.

As one of our philosophers has pointed out, man has never given the machine age a real trial. To date there has been only a rehearsal. This reveals magnificent instruments, many talented musicians and actors. There is no score, no libretto and no conductor. Still it may be a great show someday.

—PHILIP W SWAIN

Millers Ford—Built to Run

We have often talked about designing plants for convenient operation and maintenance as far as existing limitations permit. Here is a nearly perfect example

WE HAD HEARD so much about Millers Ford Station of The Dayton Power & Light Co that we dropped in one day to see for ourselves. We think any visitor will be impressed by the convenience of the layout from an operating standpoint and the spotless cleanness.

Two things about this station for your book: in December 1937, the first generator to operate commercially with hydrogen cooling demonstrated a 20% saving in no-load steam consumption, comparing its own performance with air and then with hydrogen; second, the "boiler chief", "turbine operator" and "pump tender" can all be one man, operating floors of boiler and turbine rooms being at the same level without separating partition.

On the Miami River, three miles from the center of Dayton, Ohio, the station now has a capacity of 135,000 kw. Originally, in 1918, two 12,500-kw units were installed for operation at 230 lb, 550 F. By 1928, three 20,000-kw and one 25,000-kw units had been added and in 1937, the 25,000-kw top was placed in service.

Top Offers Advantages

Since 230-lb equipment completely filled the existing building and because summer stream flow is limited, a top turbine offered advantages in space requirements as well as in not increasing circulating-water needs. The new turbine in the old boiler house occupies part of the space formerly taken by three of the oldest low-pressure boilers. The new boilers and their auxiliaries are housed in a 100-ft square addition. New offices, locker room and laboratory space have been provided as part of the construction.

There is space available for a future topping turbine. Removal of three more old low-pressure boilers will make space for the two future high-pressure boilers.

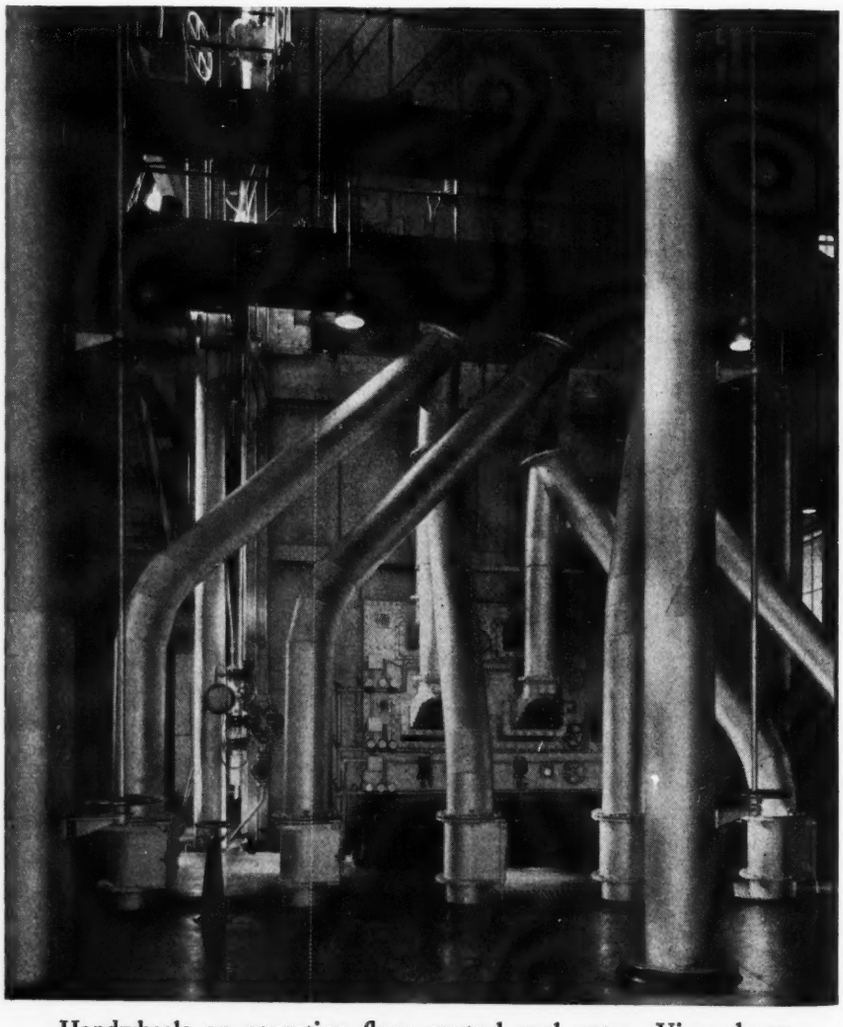
Adequate space for maintenance is not accidental. The ample steel-frame building extension has concrete floors, brick-and-tile walls. Interior walls are buff glazed tile and boilers are brightly painted with aluminum, presenting a pleasant appearance. Ample lighting, both natural and artificial is provided.

The two boilers are rated at 375,000 lb per hr each, and gas passages are divided for superheat control. Each boiler is supplied by three pulverizers located below the operating floor.

Coal is received by rail and dumped from cars to a track hopper. A new 150-ton skip hoist supplies the entire station. The bunker for the new boilers has a capacity of 950 tons.

An electric precipitator removes fly-ash, which is then carried by a vacuum system to an outside ash-storage tank. Ash from the furnace is also delivered to this tank.

Well-water makeup, softened and filtered in the old plant, is evaporated in a 20,000-lb-per-hr evaporator. The 750,000 lb-per-hr deaerating heater has a storage capacity of 125,000 lb. It also collects condensate from low-pressure turbines, exhaust steam from low-pressure plant auxiliaries, evaporator steam-coil condensate, and drain from



Handwheels on operating floor control coal gates. View shows burner arrangement and fuel piping

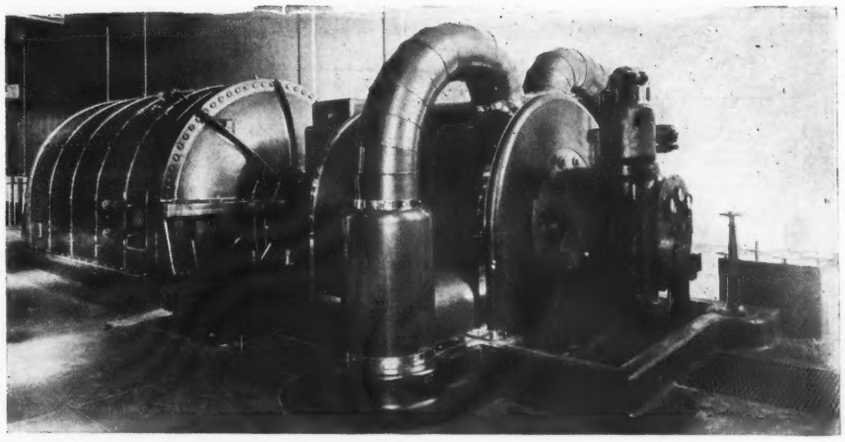
the crossover heater. Water leaving the heater flows by gravity into the primary-feed-pump suction header.

Turbine- or motor-driven primary boiler-feed pumps supply water to the secondary boiler-feed header through an evaporator condenser. The 6-stage secondary boiler-feed pumps are turbine driven. Two of the 1000-hp turbines are designed for direct use of high-temperature 1200-lb steam and exhaust at crossover pressure, 230 lb. The third, for starting and emergency, uses 230-lb steam. These pumps and drive-turbines are on the operating floor and the operator can check instantly any abnormal condition by signal lights on their control panel.

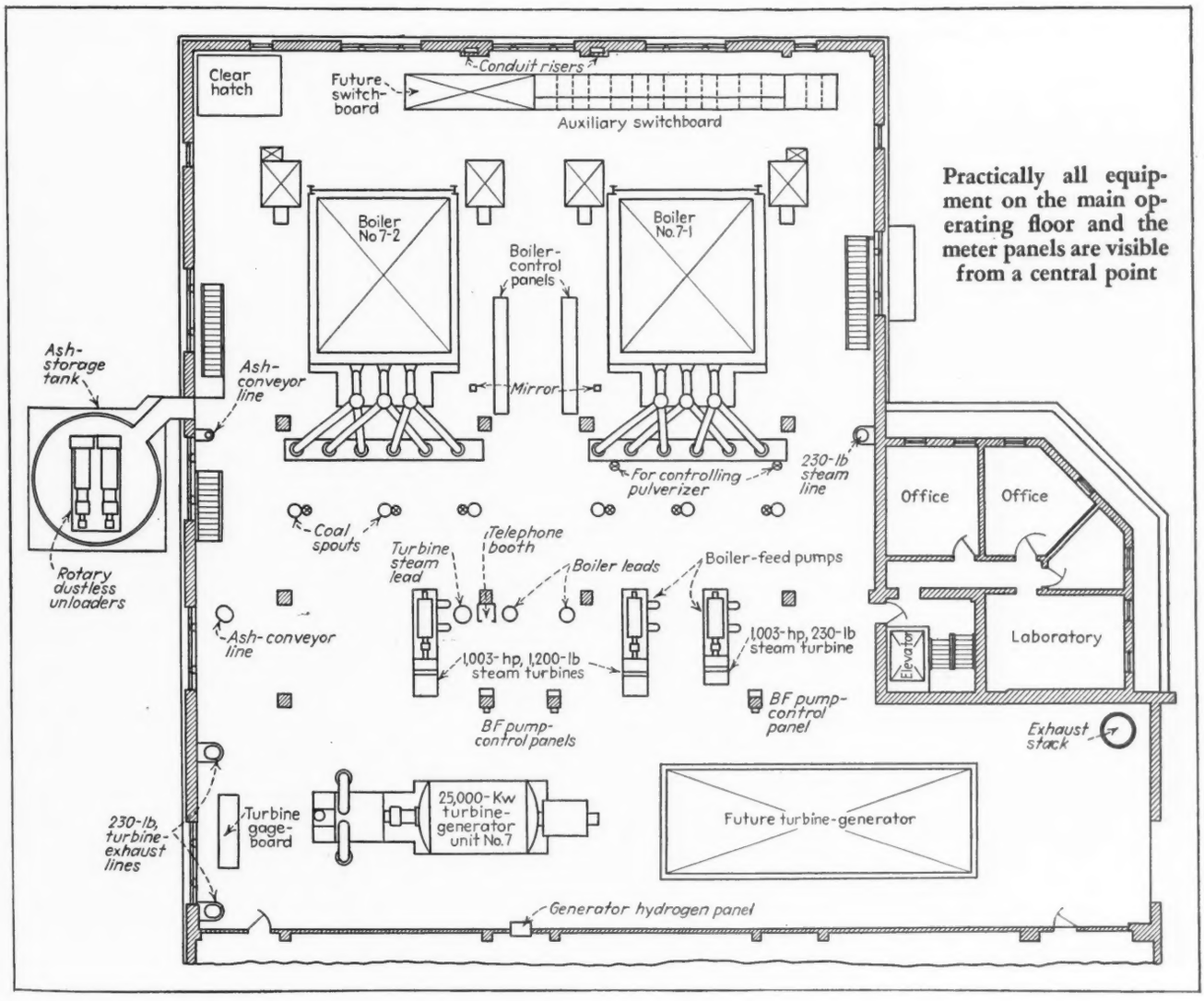
The main turbine is in an open bay with adequate floor space for disassembled turbine parts. Two separate panels carry turbine and generator instruments. The turbine itself is double-shell design, the space between shells being filled with steam at intermediate pressures to reduce temperature and pressure stresses.

This generator has the distinction of being the first to operate commercially with hydrogen cooling. After a short period of operation with air cooling, the introduction of hydrogen so reduced the generator losses as to save about 20% (about 20,000 lb per hr) of the no-load steam consumption, a very practical demonstration of the advantage of hydrogen cooling large units. At a given load, the generator also operates with lower winding temperatures when hydrogen cooled. For one month, 1320 cu ft of hydrogen were needed to maintain a slight pressure in the generator casing to insure against air infiltration. Hydrogen is kept in the generator even during periods of turbine overhaul.

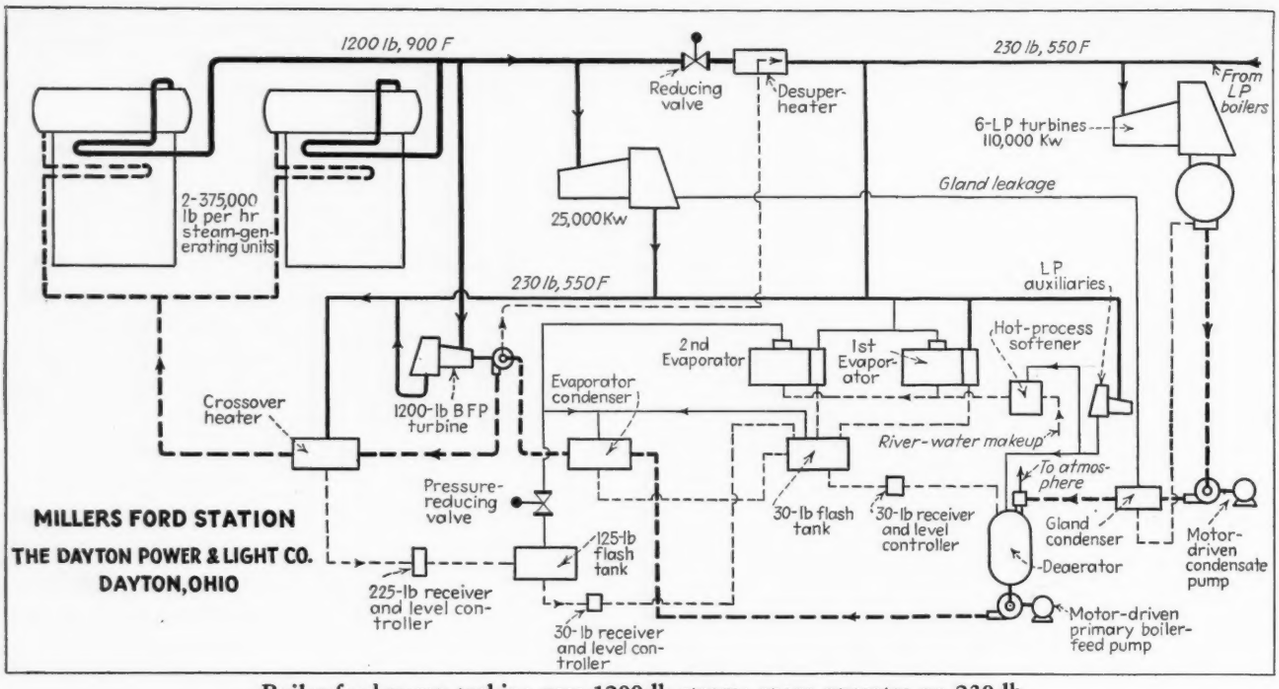
A back-pressure regulator can be used to regulate load for the turbine to maintain 230-lb exhaust pressure.



This is the first hydrogen-cooled generator to operate commercially



Practically all equipment on the main operating floor and the meter panels are visible from a central point



Boiler-feed-pump turbine uses 1200-lb steam; spare operates on 230-lb

Principal Equipment—Millers Ford Station

THE DAYTON POWER & LIGHT CO, DAYTON, OHIO
ENGINEERS—COLUMBIA ENGINEERING CORP.

Steam-Generating Equipment:
Boilers, two, heating surface, 4091 sq ft.....Babcock & Wilcox Co
375.000 lb hr at 1250 lb, 900 F, 23 tubes wide, sectional header. Tubes 4 in. od, 0.395 in. thick
Superheater, continuous tube, 10,500 sq ft.....Babcock & Wilcox Co
Upper bank, 19 rows, carbon steel, 2½ in. od, 0.282-in. wall Lower bank, 7 rows, chrome-moly steel. 57 sections wide
Furnace, 12,100 cu ft, 3¼ in. od, 0.425-in. wall...Babcock & Wilcox Co
2093 sq ft block covered, 742 sq ft stud tube, 80 sq ft bare
Economizer, continuous tube, 18,200 sq ft.....Babcock & Wilcox Co
Upper bank, counter flow, 24 tubes high; lower bank, parallel flow, 17 tubes high; 57 sec wide. Tubes, 2½ in. od, 0.282 thick
Soot blowers, 26, sla° blowers, 4.....Diamond Power Specialty Corp
Safety valves, 4 drum, 2 sup.....Consolidated Ashcroft Hancock Div
Power-control valve.....Consolidated Ashcroft Hancock Div
Feedwater-regulating valve.....Republic Flow Meters Co
Feedwater control, 3-element type.....Bailey Meter Co
Combustion control and superheat control.....Leeds & Northrup Co
Blowoff valves.....Edwards Valve & Mfg Co

Pulverized-Coal Equipment:
Pulverizers, 3 per blr. 7 tph each, type B.....Babcock & Wilcox Co
Pulverizer drive 125-hp, 1200 rpm sc motor...Allis-Chalmers Mfg Co
V-belt drive, Bailey automatic mill-level control
Blower, single inlet, overhung wheel.....B F Sturtevant Co
Blower drive, 50-hp, 1800 rpm sc motor.....Allis-Chalmers Mfg Co
Coal feeders, 3/blr. 22½-in. rot. table type.....Babcock & Wilcox Co
Driven by ¾-hp 1800 rpm sc motor
Coal burners, 6/blr. horizontal, cross tube.....Babcock & Wilcox Co
118.5 million Btu per hr. each. Automatic gas lighters.

Coal-Handling Equipment:
Track hopper, capacity 150 tons.....C O Bartlett & Snow Co
Automatic weigh-type loading gate for skip hoist
Skip hoist, single bucket, 175 cu ft.....C O Bartlett & Snow Co
Travel, 150 ft, speed, 270 fpm, 150 tph
Skip-hoist drive, 65-hp motor.....Lincoln Electric Co
Drive control.....Cutler-Hammer, Inc
Apron-feeder conveyor, 150 tph, speed 21 fpm..C O Bartlett & Snow Co
Double-beaded steel plates carried by 2 strands of chain, 3 hp
Drive, 160-to-1 speed reducer.....Falk Corp
Coal screen, 4x6 ft, single deck, 1½-in. mesh.....W S Tyler Co
Drive, 5-hp motor.....Allis-Chalmers Mfg Co
Cross conveyor, 150 tph, 30-in. belt.....C O Bartlett & Snow Co
275 fpm, 76-ft centers, rise 9½ ft. Magnetic-head pulley
Drive, 7½-hp motor with Falk reducer.....Allis-Chalmers Mfg Co
Distributing conveyor, 30-in. belt,.....C O Bartlett & Snow Co
275 fpm, 85-ft centers, equipped with tripper
Drive, 7½-hp motor with Falk reducer.....Allis-Chalmers Mfg Co
Suspended bunker, 950 tons, 26x87x20 ft deep..C O Bartlett & Snow Co
Coal spouts, 6, 18 in.....C O Bartlett & Snow Co
18-in. square gates operated by handwheel from operating floor
Coal scales, 6, enclosed dust-confining type.....Richardson Scale Co
Hopper capacity, 300 lb, 10 tph. Driven by ¼-hp motor

Ash-Handling System:
Vacuum system.....United Conveyor Corp
Ash-pit hoppers, lined with 7-in. firebrick, 2½ in. Silocel 8-in. Durite pipeline with self-feeding ash intakes, 8-in. Durite flyash line with gear-motor operated measuring hoppers and vibrating dischargers for continuous discharge
Receiver and separator, Durite, heavy-duty.....United Conveyor Corp
Bag-filter arrester, automatic vacuum breaker with silencer, positive displacement vacuum pump driven by 100-hp motor
Ash-storage tank, 100 tons, bin-indicator.....United Conveyor Corp
3 dustless rotary unloaders, 20 tph each driven by 5-hp motors

Draft Equipment:
Induced-draft fans, 200,000 cfm, 450 F, 15 in.....Buffalo Forge Co
Hydraulic coupling, 42 in.....American Blower Corp
Drive, 700/450-hp, 875/905-rpm, sc motors.....Allis-Chalmers Mfg Co
Forced-draft fans, 113,000 cfm, 100 F, 12 in.....Buffalo Forge Co
Hydraulic coupling, 30 in.....American Blower Corp
Drive, 300-hp, 1175-rpm, sc motor.....Allis-Chalmers Mfg Co
Air preheaters, 26,370 sq ft/blr.....Babcock & Wilcox Co
2-pass, horizontal tubular, 60 rows of 20 tubes, 16 ft long, 2½ in. od, 0.083-in. wall. Air temp out, maximum 428 F.
Precipitators, 1 per blr.....Research Corp
Fullwave rectification, 2, 15-kw, 440/75,000-v transformers

Boiler-Feed System:
Crossover heater, 2927 sq ft, 4-pass, lockhead.....Foster Wheeler Corp
780,000 lb/hr, outlet temp 398 F.
Gland-steam condenser, 69 sq ft, 2400 lb/hr.....Foster Wheeler Corp
Deaerating heater, 750,000 lb/hr.....Worthington Pump & Mach Corp
With vent condenser and 125,000 lb storage tank
Evaporator condenser, 1185 sq ft, 30.000 lb/hr.....Griscom-Russell Co
Evaporators, double effect, 20,000 lb/hr.....Foster Wheeler Corp
Evaporator feed pumps, 2, 1½ in.....Worthington Pump & Mach Corp
2-stage, 20,000 lb/hr, 204 F, 303 ft tdh
Drive, 10-hp, 3600-rpm, sc motors.....Allis-Chalmers Mfg Co
Primary boiler-feed pumps, 2, 1000 gpm.....Platt Iron Works
6 in., 3 stage, centrifugal, 690 ft tdh
Drive, 300-hp, 1800-rpm, sc motor.....General Electric Co
Drive, single-stage, 230-lb turbine.....General Electric Co
Secondary boiler-feed pumps, 3, 6 stage.....Allis-Chalmers Mfg Co
415.000 lb/hr, 250 F, 1500 lb
Drive, 1003-hp turbines, 2-1200 lb, 1-230 lb.....General Electric Co

Generating Equipment:
Turbine, 25,000 kw, 11 stage, 3600 rpm.....General Electric Co
1200 lb, 900 F, exhaust at 230 lb
Generator, 12,000 v, hydrogen cooled.....General Electric Co
Exciter, 100 kw, 250 v, 1778 rpm, driven through gear
Pilot exciter, 2 kw, 250 v, on exciter shaft

Desuperheater and Reducing Valve:
Desuperheater, 375,000 lb/hr, venturi type.....Republic Flow Meters Co
35-cu-ft water reservoir and level regulator
Reducing valve, 390,000 lb/hr.....Republic Flow Meters Co

Piping:
Contractor.....Pittsburgh Piping & Equipment Co
Insulation.....Owens-Illinois Glass Co
Large Valves.....Wm Powell Co
Small valves.....Edwards Valve & Mfg Co

Metering Equipment:
Recording pressure gages.....Foxboro Co
Indicating thermometers.....Foxboro Co
Draft gages, CO_2 recorders.....Republic Flow Meters Co
Temperature recorders, conductivity meters.....Leeds & Northrup Co
Indicating pressure gages.....Consolidated Ashcroft Hancock Div
Steam and water flowmeters.....Bailey Meter Co

Electric Equipment:
Control desk, 7 section.....Westinghouse Elec & Mfg Co
Generator voltage regulators.....Westinghouse Elec & Mfg Co
Circuit-breaker interlocks.....Bendix Marine Products Co
Auxiliary power transformers, two 3750 kva.....Allis-Chalmers Mfg Co
Auxiliary switchboard, 460 v..... I T E Circuit Breaker Co
Feeder cable, 440 v, Glyptal insulated.....General Electric Co
With lead sheath and interlocking bronze armor
Control cable.....Rockbestos Products Corp
Elevator, passenger, push-button control.....Otis Elevator Co

Under present operating conditions, the turbine is controlled by the speed governor and 230-lb pressure is regulated by adjusting low-pressure boilers.

All high-pressure steam and water lines are welded wherever possible. Ends of pipe 3 in. and larger were upset and recessed for solid chill rings. Carbon-moly steam lines were preheated to 550 F before and during welding operations. Stress relieving at 1200 F was maintained for four hours per in. of wall thickness and brought down to 500 F at the rate of 200 F per hour. Temperatures were controlled automatically and recorded on a separate chart for each weld. For the carbon-steel water lines, the same procedure was followed except for preheating. No leaks were found in any welds during hydrostatic test.

All high-pressure steam and water valves have cast carbon-moly bodies. Seats and disks have stellite welded-on seat faces. Non-return valves are of the same materials and are toggle operated.

The high-pressure turbine required removal of three low-pressure boilers, reducing plant steaming capacity; the new boilers were therefore placed in service several months in advance of the turbine. Consequently, from April to September, 1937, steam was supplied to the low-pressure header through a reducing valve and desuperheater which bypasses the turbine. Water for desuperheating is taken from the second stage of the boiler-feed pump.

Electrically driven auxiliaries are supplied at 440 v, all motors being 3-phase, squirrel cage, designed for line starting. Transformer banks are isolated from the interior of the station in fireproof vaults. A tie is provided to two existing banks in the low-pressure station.

Bronze-Armored Cable

The auxiliary switchboard has totally enclosed air circuit breakers and bus, divided into four sections. Main feeders are high-temperature varnished-cambric-insulated cable with a lead sheath and interlocking bronze armor. Where not concealed in sheet-metal pans or conduit, the racked cable presents a neat and workmanlike appearance, the bronze adding to, rather than detracting from, the bright appearance of other aluminum surfaces.

Extensive changes to the electrical galleries include increasing the interrupting capacity of the existing oil circuit breakers by the addition of deion grid contacts. Feeder capacity has been increased by establishing a 12,000-v bus and operating half the existing feeders at that voltage. Bus voltage for the old station was 6900. The new bus is entirely metal clad.

The new generator, operating at 12,000 v, feeds this bus directly. The 25,000-kw low-pressure unit has been reconnected for 13,200 v, and feeds the new bus through an auto-transformer. Control of all generators and 66-kv tie lines is centralized in a new 7-section steel control desk.

For the year 1936, the low-pressure plant had a heat rate of 19,941 Btu per kwhr send out. For the month of February, 1938, the heat rate was 16,926 with the turbine running 26 days. Of this period, two boilers operated 15 days; the rest of the time, only one high-pressure boiler was in service. Under normal conditions, a combined heat rate of 13,850 Btu per kwhr is expected.

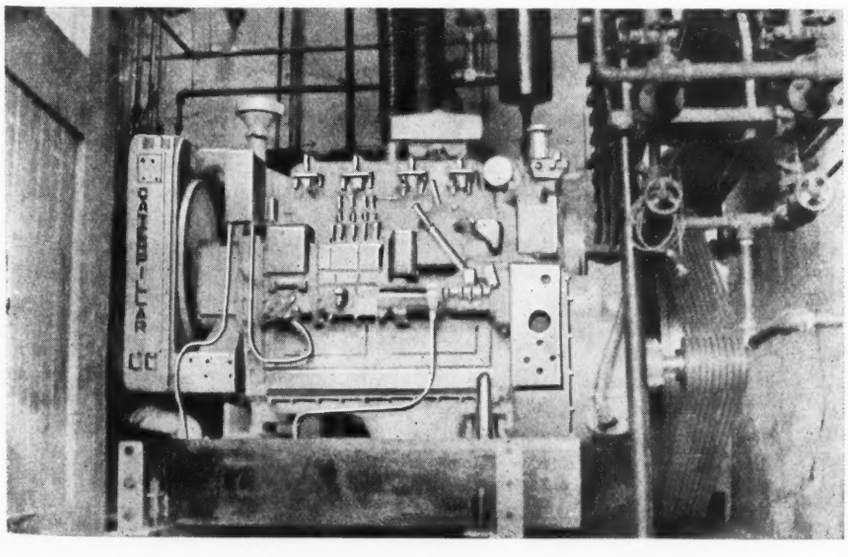
✦ ✦ ✦

Diesel Does It Cheaply

By FRANCIS A WESTBROOK

A NEW DIESEL at the M H Laipson Creamery, Worcester, Mass., drives a 6½ x 6½-in. ammonia compressor at an operating cost substantially lower than the former 20-hp motor.

A 4-cyl, 4-cycle water-cooled unit, the engine is rated for a continuous load of 33 hp at 1400 rpm. Cylinder bore is 4½ in. and stroke is 5½. Present loading (the ice machine) is well under 33 hp, so the engine operates at 1200 rpm. Plans call for the later installation of a small generator, to be belt-driven from the engine, and to provide electrical power for a deepwell pump.



One of the most interesting features of this installation is the engine-compressor drive. A space 20 x 20 ft has to do for both engine and ice machine. V-belts connect the 6-in. driving pulley with the 48-in. driven pulley, with only 49 in. between centers. Nine V-belts are used, and the large pulley is crowned instead of grooved, an unusual arrangement. Operation of the drive has been highly satisfactory.

Sliding Base

Mounting the engine on a sliding base as shown in the photograph insures proper belt tightness. A flexible exhaust pipe with slip joint makes movement of the engine possible.

The engine consumes about one gal. of fuel oil every hour when driving the compressor under full load. At 6½ cents, this represents a real saving over the cost of electric power which had been about 30 cents per hour. Run, on the average, 9 hrs a day for 7 days a week (about 6 hrs per day in winter and 16 hrs a day in summer), the unit has seen a year's service with no expense of any kind for repairs.

Bbl Salt / Lb Coal

System of accounting for power and process steam, evolved and tested in 14 years of experience, stops waste

BY M J GEARING
Diamond Crystal Salt Div, General Foods Corp

UNTIL LATELY, most processing plants have looked upon power and steam generation as necessary evils incidental to the conversion of raw material into finished product. Direct material and labor costs have always received respectful attention; cost surveys of steam and power only recently earned their important place in progressive plant accounting.

A pioneer in this field, the Diamond Crystal Salt Div of St. Clair, Mich., now a unit of General Foods Corp, generates its own electric power, using exhaust steam for process and heating. Live steam drives small auxiliaries, such as pumps and air compressors, which also exhaust to process and heating.

Fifteen years ago an intensive "power survey" developed methods for determining and controlling power costs to be apportioned among various departments in accordance with actual use. Previous occasional and uncoordinated efforts at metering coal and electrical output told only a small part of the needed information, drops in the bucket as far as true power economy was concerned. The annual coal bill of $450,000 justified considerable investment in equipment that could get results.

Planning a system of supervision of power production and distribution was not a simple matter. It had to be complete but not unwieldy or burdensome. Of many items that might have been recorded a selection was made of those most immediately valuable to the analysis of operating conditions and costs.

Operations were classified: (1) production of steam, (2) distribution and use of steam, (3) production of electric power, and (4) distribution and use of electric power. The planning job was split up (1) information needed, (2) instruments, (3) forms and log sheets, (4) changes to piping and equipment, (5) organization and duties of personnel.

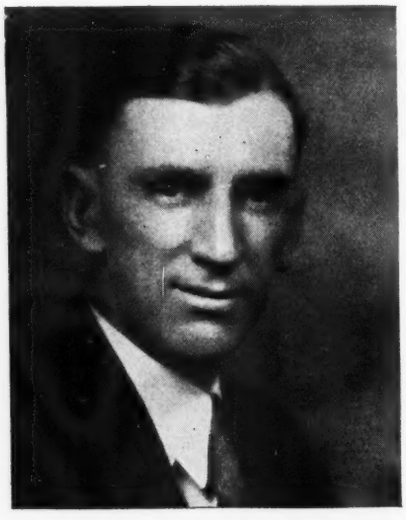
For the first item, production of steam, the information collected consists of data for determining unit cost of making steam and a record of operating conditions under which such costs are obtained. Individual boiler records are kept so that comparison among the boilers provides better control of operation. So much work was involved in gathering data by shifts that the practice was abandoned, comparison now being made on a 24-hr basis. Results obtained by the personnel of the various shifts may be compared by reference to recording-instrument charts.

Instruments

Instruments are a feedwater flowmeter and temperature recorder, makeup flowmeter and temperature recorder and a recording coal scale to show total coal delivered to the boiler room. On each boiler are combustion-control instruments, steam flowmeters and coal scales. Wherever possible, instruments of the recording type are used. A steam flowmeter and kilowatt-hour meter measure services used by the boiler room.

Data collected on the distribution of steam to the various departments is classified according to pressure as well as flow, steam being supplied at several different pressures. Flowmeters measure steam to each department but do not segregate the steam consumption of individual units within a department. Special arrangements are made for such occasional tests on individual equipment as seem desirable. In some cases, the exhaust steam use varies so little or can be calculated within such close limits that flowmeters are not required.

The flowmeters are electric, which permits grouping the records and integrators at a central point for convenience in reading and chart changing. This centralization makes it possible for the superintendent to check at a glance steam flow to all departments. Indicators in the several departments provide information that has proven decidedly advantageous in the control of their operations. Of the twenty meters required for measuring steam distribution, most are of the indicating, recording and integrating type. A large amount of steam piping was revamped and relocated to install meters to best advantage.



"Power records complete but not unwieldy. Salt production up 80%"

Information on power production includes steam flow to prime movers and total electricity produced, initial and exhaust pressures, and similar data. Control instruments are also provided. A single steam flowmeter measures all steam for power generation, but a kilowatt-hour meter is provided for each generator. Most of the power is generated by a noncondensing turbine generator. There are also two standby condensing units. Steam consumptions of the latter are determined by measuring their condensate, making it possible to ascertain steam use of the main unit by

DIAMOND CRYSTAL SALT CO.

DAILY POWER RECORD

FOR 24 HOURS COMMENCING AT 7 A. M. _____ 193____

PRODUCTION OF POWER

BOILER HOUSE		GENERATOR ROOM		AUXILIARIES	
Pds. Live Steam Made		Pds. Live Steam Used		Pds. Live Steam Used	
Av. Live Steam Pressure		K. W. Hrs. Made		Pds. Low Press. Exhaust Steam Used	
				K. W. Hrs. Used	

DISTRIBUTION OF POWER

Av. High Exhaust Steam Pressure Av. Low Exhaust Steam Pressure		Pounds of Live Steam Used		Pds. of High Press. Exh. Steam Used		Pds. of Low Press. Exh. Steam Used		Total Steam	K. W. Hrs. Used	
DEPARTMENT	Bbls. Salt Made	Total	Per Bbl.	Total	Per Bbl.	Total	Per Bbl.	Per Barrel	Total	Per Bbl.
A System										
B System										
C System										
D System										
E System										
F System										
Total of Alberger Systems										
Undried Medium										
K. D. Medium										
Undried Granulated										
K. D. Granulated										
Total of All Salt Making Sys.										
Well Pumps and Air Compres.										
Gen. Serv. Pumps & Air Compr.										
Cooper Shop										
Can Manufacturing										
Packing and Shipping										
Block Press										
Construction and Maintenance										
General Heating and Miscellan.										
General Lighting										
Residences										
High Pressure Reducing Valve										
Low Pressure Reducing Valve										
TOTALS										

Remarks:

DIAMOND CRYSTAL SALT CO.

MONTHLY POWER COST REPORT

For Month of _____ 193____

Form E-19

MANUFACTURE OF POWER

BOILER HOUSE		ENGINE ROOM	
Average Boiler Horsepower Developed		Average Day Load in K. W.	
Average Percent of Rating Developed		Average Night Load in K. W.	
Average Actual Evaporation—Coal as Fired		Average 24 Hr. Load in K. W.	
Average Equivalent Evaporation—Dry Coal		Average Day Load Factor	
Average Overall Efficiency—Boilers and Stokers		Peak Load	
Average Net Equivalent Evaporation—Dry Coal		Peak Load Factor	
Average Net Overall Efficiency--Boilers, Stokers, Aux.		Average Thermal Efficiency	

Average Net Overall Thermal Efficiency—Coal Bunker to Switchboard

Pds. Steam Made		K. W. Hrs. Made	
Pds. Steam Used by Boiler House Auxiliaries		K. W. Hrs. Delivered to Boiler House Auxiliaries	
Pds. Steam Delivered Direct to Factory		K. W. Hrs. Delivered Direct to Factory	
Pds. Steam Delivered to Factory as Electricity		Cost of Steam for K. W. Hrs. Delivered to Factory	
Total Pds. Steam Delivered to Factory		All Other Engine Room Expense	
Total Boiler House Expense		Total Cost of K. W. Hrs. Delivered to Factory	
Cost per 1000 Pds. Steam Delivered to Factory		Cost per K. W. Hr. Delivered to Factory	

A System	
B "	
C "	
D "	
E "	
F "	
Total Alb. Systems	
Grainers	
Vacuum Pan	
Total of Salt Systems	
Pumps & Air Comp.--Wells	
Pumps & Air Comp.--Misc.	
Cooper Shop	
Packing Building	
Block Press	
Shipping	
Offices	
Constr'n and Maint'ce	
Residences & No. 5 Well	
Heating System	
Lighting System	
TOTALS	

Remarks:

DIAMOND CRYSTAL SALT CO.

DAILY POWER PLANT LOG

LOG OF BOILER HOUSE

FOR 24 HOURS COMMENCING AT 7 A. M. _____ 193____

Boiler Number	1	2	3	4			All Boilers
Steam Pressure Pds. Gauge							
Pounds Coal Used—As Fired							
Total Moisture in Coal—%							
Pounds Dry Coal Used							
Pounds Feed Water Used							
Pounds Steam Made							
Actual Evaporation—Coal As Fired							
Av. Temperature of Feed Water							
Av. Factor of Evaporation							
Equivalent Evaporation—Dry Coal							
Overall Boiler and Furnace Efficiency							
Av. Flue Gas Temperature							
Av. Boiler H. P. Developed							
Rated Boiler H. P.							
Per Cent. of Rating Developed							
Hours in Service							
Hours Since Last Cleaned							
Pds. Make-up Water Used							
Av. Temp. of Make-up Water							
Av. Temp. of Low Press. Returns							
Av. Temp. Water Leaving L. P. Heater							
Av. Pressure on L. P. Heater							
Av. Pressure on H. P. Heater							

Remarks:

APPROXIMATE ANALYSIS OF COAL	
Kind of Coal	
Moisture	
Volatile Matter	
Fixed Carbon	
Ash	
B. T. U.—Dry	

LOG OF GENERATOR ROOM

Generator	K. W. Hours Made	Pds. Steam Used	Pds. Steam Per K. W. Hr.	Av. Steam Pressure	Av. Back Pressure	Av. Vacuum	Av. Voltage	Average Load: Day	Average Load: Night	Average Load: 24 Hrs.	Cap'y Factor	
No. 1												
No. 2												
No. 3												
Total												

Remarks:

subtracting the amount of condensate from the total shown by the steam flowmeter. In this manner steam rate per kwhr can be calculated for each unit.

To measure the distribution of electricity, there are 21 kilowatt-hour meters in the various departmental circuits. The wiring is arranged to permit grouping the meters on the power-plant switchboard for convenience.

All meters are read and recorder charts changed daily. Data thus collected is tabulated on forms expressly designed for the purpose. The record of power-plant operation is entered on the "Daily Power-Plant Log" which is subdivided into two parts, "Log of Boiler House" and "Log of Generator Room." All important data pertinent to operation are shown, including steam production, coal consumption, average pressures and temperatures of steam and feedwater, average boiler loads, drafts and flue-gas temperatures. For the generator room are kept the kwhr output, steam consumption, average generator loads, steam rates and similar data.

Power Distribution

The record of power distribution is shown on "Daily Power Record," subdivided into two parts under the headings "Production of Power" and "Distribution of Power." Total quantities of both steam and electricity used are shown and for the various departments; the amounts used per barrel of salt or other unit of production are also given. Total live-steam use from the distribution meters is checked against boiler output as shown by the feedwater meter after adjustment of the latter reading for blowdown and other losses. Our experience shows that the difference, or error, between the two totals is remarkably small, considering the large number of meters used in recording.

These two records bring to the superintendent and the foremen concerned actual steam and power quantities, enabling proper control and quick detection of losses.

Since most of the steam is used twice, once as live steam and again as exhaust, the total steam use shown exceeds the amount made. To provide an equitable method of charging the steam among the departments, a "Steam Charge Distribution Report" works out a steam balance charging each department for steam on the basis of the heat actually used, credit being allowed for heat remaining in the exhaust steam. Where steam is condensed and the condensate returned to the boilers, credit is also given for heat remaining in the condensate. For convenience, this is worked out on a percentage basis, "pounds of steam" being retained as the measuring unit.

Heat remaining in the condensate is considered as used by the boiler-room auxiliaries and deducted from the total steam made as is other steam used in the boiler room. This gives a figure in "pounds of steam" corresponding to the net heat actually delivered to the factory. From this total is derived the unit cost of steam to be used as the basis for charging the individual departments. Similarly, electricity used for driving power-plant auxiliaries is deducted from the total made, the balance being the amount actually delivered and charged for.

A steam and power balance is worked up daily and at the end of the month the figures are totalled on another sheet, the "Monthly Power-Cost Report". This report is also subdivided into "Manufacture of Power" and "Distribution of Power." Under the former are shown the average load, evaporation, and efficiency of the boilers, the total steam made and delivered, and the total fuel cost and fuel cost per thousand lb of steam made and delivered. Similar data for the generator room includes average loads, day, night, and 24-hr, peak load, total kwhr made and delivered, and fuel cost per kwhr. On the distribution side are shown each department's total steam and power use with corresponding fuel costs calculated from the unit costs for manufacture of power. Costs for steam and power are totalled for each department. These totals are then used to determine a factor for apportioning among the departments all other power-plant expense beside fuel.

Power Clerk

Collection of data and preparation of reports is done by one man known as the "Power Clerk" with some assistance in changing charts and reading meters. He also cares for the meters, inspecting and checking on a regular schedule. In addition, regular service calls are made by representatives of the companies which furnished the meters.

This system of power accounting has been in use for the past fourteen years and its cost has been justified many times over. Since its installation, the salt production per ton of coal has increased about 80% in the face of additional demands for power. While the accounting system cannot claim responsibility for all this fuel saving, it has played an important part in (1) locating and stopping leaks, detecting and correcting faulty operation in both production and consumption, and (2) by providing data on which to base calculations of savings possible through improved methods and the installation of more efficient equipment. It has also provided a logical and accurate method of determining and allocating department power costs.

✦ ✦ ✦

Questions for Boiler-Room Engineers

THESE QUESTIONS are similar to those asked in some of the better-arranged state examinations for licenses to operate steam boilers. Use them as an aid in interviewing and selecting power-plant employees, and as a review of important features of boiler-room operating practice. From time to time *Power* will publish additional questions of this type.

By Harry M Spring

Q—What would you do if you could not see any water in the glass and the three try cocks showed steam?

A—Shut the boiler down at once: leave the rear damper open, close all draft under the fire, and blanket fire with wet ashes or coal. Use a fire hose in an emergency. Do not change any valve positions until evaporation has ceased; then close main stop valve if there are other boilers on the line.

Q—How do you try a safety valve and how often?

A—Raise it from the seat with the lifting lever each day of operation. To check the blowing point, raise the pressure at least once a month.

Q—What do you do first on taking over a shift in the boiler room?

A—Blow down the gage glass, water column, and check gage cocks to be sure of water level.

Q—How would you know if the blowdown pipe was obstructed?

A—Vibration can be felt, and flow through the pipe under pressure can be heard.

Q—What causes a gage glass to break?

A—A scratch from cleaning the glass, a cold draft, or drops of cold water are common causes. Also, the glass may be too long to allow for expansion.

Fire Protection at Empire State

The fire brigade at the world's tallest skyscraper has a specially equipped truck that can be whisked around to any part of the building

By ANDREW E PELZER
Asst Operating Manager, Empire State Bldg

MODERN SKYSCRAPER office buildings are practically fireproof, but the offices, stores, store rooms, restaurants, etc., contain combustible and inflammable materials. Adequate fire protection must be provided to bring a fire under control quickly and with a minimum of damage. Engineers at the Empire State Bldg, New York, N. Y., after an exhaustive study of the problem, decided to provide fire protection in addition to the usual hose lines and portable extinguishers required by law.

Fire fighters in a building have so little fire fighting to do that, no matter how efficient their fire drills may be, they are at best amateurs. When experts from the city fire department go out to fight a fire, they go equipped with everything from mascots to hook and ladder trucks. Therefore, we reasoned that our men should be equally well equipped.

Portable Truck

With this idea in mind, we developed a specially equipped hand fire truck that is easily handled by one man and can be taken onto any elevator or through any door in the building, even an office gate. Now, when our firemen arrive on the job, no time is lost in going after the portable equipment on the floor, as everything is at hand to work with. This allows training the men into a more efficient working unit, gives better control over their efforts and reduces confusion to a minimum.

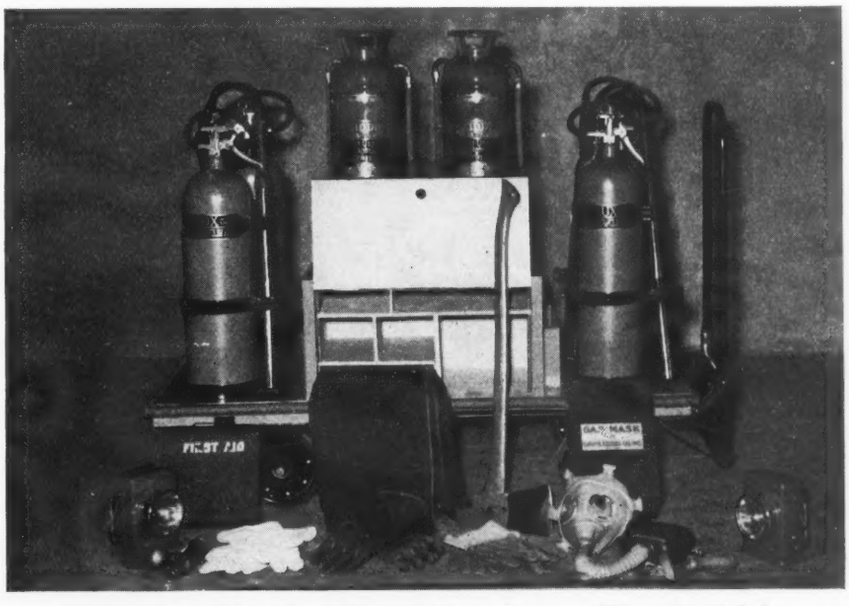
The truck body is mounted on 4 ball-bearing rubber-tired casters and it is equipped with a self-righting handle that always goes to a vertical position when released. The latter is a safety feature to prevent fire fighters from tripping over the handle. A rubber-strip bumper all around the truck platform prevents damage to painted or other surfaces.

On the truck shown in the figure are assembled four 15-lb CO_2 extinguishers with nozzles and four 2.5-gal. pure water extinguishers with pressure gas charges. The CO_2 extinguishers are arranged across the front and rear of the truck with the water extinguisher placed on top of the auxiliary equipment chest in the center of the truck. Each of the CO_2 extinguishers is held securely in place by an easily released running-board clamp and the water extinguishers set free in deep cylindrical pockets attached to the truck. Other equipment carried on the outside of the truck includes a short pike pole, a pinch bar and an axe.

Stored in a cabinet in the center section of the truck are two battery flood lights and extra recharges for the pure-water extinguishers, a gas mask, a pair of asbestos gloves, a pair of high-tension rubber gloves with leather protection for handling live electric circuits, a fireproof blanket and a first-aid kit. This kit includes ammonia inhalants, burn ointment and dressings, eye ointment, material to sterilize lacerations, and a tourniquet.

Fire-Fighting Equipment

On this truck there is assembled all equipment necessary to extinguish quickly and safely any fire that may occur in the building. In addition to this equipment, there are 585 2.5-gal. soda-acid extinguishers distributed through the building. In elevator-machine rooms, pump rooms, switchboard rooms and other places containing electrical equipment are about 100 CO_2 extinguishers. Built-in CO_2 systems protect paint- and oil-storage rooms. In the sub-basement are one portable 40-gal. foamite and two 40-gal. soda-acid extinguishers that may be taken to any part of the building. Hose lines are also at each floor on standpipes at strategic points. This equipment acts as second and third lines of defense to the fire-fighting truck and its equipment.



Cabinet in center of truck opened to show auxiliary fire-fighting equipment—everything from gloves to a tourniquet

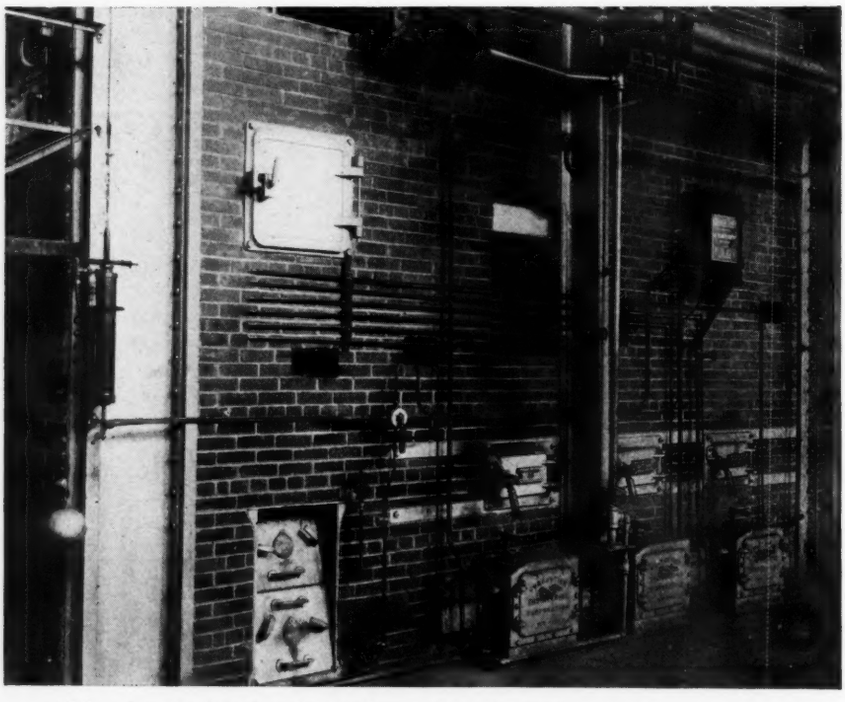
Make the Best of Your Old Plant

It isn't always necessary to scrap "old faithful"—small improvements cost little, and do a lot to boost efficiency

By STUART W ALLEN*

ARE YOU one of that great body of engineers who are hopeful of junking the old wagon and starting fresh with an up-to-date plant? Most of us have had that feeling at some time and so we find it hard to understand the big boss when he agrees with the idea but "cannot see his way clear at this time," and goes on with long explanations of financial difficulties, poor business, the uncertainty of the future, and all the rest of it. We argue that cold dollars can be saved by the investment involved and get so worked up trying to prove our case that we often miss an important point. And this is that we may get nearly all the savings we were shooting for by the simple step of bringing the old hack up to date.

Before talking modernization, let's step over into the boss's shoes and see if we can't look at the picture from his point of view. He sees the power plant merely as a source of supply, and power as a commodity, just as he views all other material purchased. His aim is to put a product on the market at a figure that will meet competition and show a reasonable return on the investment. In most cases he has to borrow money to make capital improvements and with every dollar borrowed he is adding a direct monthly charge which remains fixed, regardless of business conditions or volume of output.



Side of typical industrial boiler, stoker-fired, showing furnace-pressure regulator

Remember, too, that with changing business conditions, the necessity of constantly changing and improving the product, and with improvements in production machinery, there is a never-ceasing demand for money to be spent in the production department. Most of these changes are essential to the maintenance of competitive standing and there is no choice as to whether the money should be spent or not. Having been forced to these decisions, and frequently, even in well-established businesses, being forced to do some fancy juggling financially to meet these situations, it is small wonder that sometimes little attention is paid to requests from the power department.

All of which doesn't mean that we power engineers must sit back, bemoan our fate and wistfully wait for the day when business will permit developing plants as they should be developed. Realizing that maybe the boss is right when he refuses our major requests and yet still being sure that something must be done, it is up to us to show that we are really capable of holding down our jobs. So, how do we go about it?

A Typical Plant

Let's assume a typical plant, not too hopelessly antiquated or with equipment nearing the end of its service life. Suppose we have a boiler house consisting of a number of boilers of varying age. Comparatively low ratings are carried to avoid failure in the brickwork. A low CO_2 is carried, again because of refractory maintenance, and with a number of units to be watched, it is about all that the operating force can do to maintain proper steam temperatures and boiler-water levels.

To start changing this situation, let's take a hitch in the belt and get some real dope on operating conditions. How much steam is produced? What is its quality? Is moisture being carried over to damage prime movers? Is the flue-gas loss excessive? Is brick-work maintenance per M lb steam higher than should be expected? To what extent does scale form on the tubes? What is its cost of removal? Each item has a dollar and cents value, representing losses which may be recovered in whole or in part.

So far we've got the dope—what comes next? Let's assume that we

* Mr. Allen is now a consulting engineer of Providence, R. I., but writes from many years experience as an industrial-plant engineer.

find high flue-gas temperatures, higher brickwork-maintenance costs than might be exepcted, and some indication of excessive furnace temperatures although no tube failures have resulted. On the other hand, the baffling is in good shape and proper CO_2 is being carried.

An Answer

What's the answer? Analyzing the situation, we find that the black surface, that is, the exposed boiler tube, is not of sufficient area for the amount of heat being liberated in the furnace. Because of this situation, the boiler has been held to low ratings and an additional boiler carried on the line, leaving no boiler capacity in reserve. This set-up represents an actual case, and the solution was not the installation of an additional boiler as originally recommended. Changes to existing boiler did the trick. Let's see how.

Installation of a watercooled bridge wall and slag screen in the furnace added about 35% to the effective heat-absorbing area. No material changes to boiler or setting were required and the cost was a small fraction of a new boiler's cost. Furthermore, it would have been impossible to have gotten approval for a new boiler, but little resistance was encountered when the watercooling installation was proposed. Incidentally, the saving in brickwork maintenance during the period this installation has been in service has more than paid for the cost of the job.

Another Example

Suppose we take another example—say a small industrial plant operating with low CO_2, high excess air, and consequently high heat loss to the stack. Lack of control equipment is usually to blame in such a case. After this diagnosis, we must be careful not to make the mistake of demanding equipment which is too complicated and expensive for the job. A visit to the nearby central station is apt to give us fancy ideas about applying highly automatic regulation to the industrial plant. Installations like that cost money, however, and generally mean such an increase in fixed charges that it would offset any possible operating savings.

The best net results can be gotten with relatively simple equipment. A furnace-pressure regulator, for example, may control draft and help cut excess air to a minimum. If oil is being fired, a simple arrangement of damper regulator to control fuel flow in relation to air flow may be just what is needed to increase burning efficiency. Such installations are comparatively inexpensive and, when properly installed and operated, give results which more than justify the slight expense involved.

One Thing at a Time

So it goes—in every old plant there are improvements that can be made, savings to be gained. All we've got to remember is that initial investment must be kept as low as possible, and that it is better to pick out one thing at a time and get it, than to ask for so much we get nothing at all.

Exhaust Lines

"Flies hate blue," according to a writer in *Paint Manufacturer*, who describes blue-tinted walls encountered in French hospitals. Doctors and architects alike agree that flies have a marked distaste for this color. Talks with others who have tried the same thing all seem to confirm this queer fact and to indicate that it is the color and nothing in the chemical composition of the paint that scares the insects away. Colors used in most cases have been light.

Asked to take part in a symposium on mechanical engineering, the chief engineer of one of the automobile companies was told he would have 20 minutes to discuss "Gears." His polite refusal carried no hint of what he thought about the intelligence level of people who thought a subject like that could be covered in 20 minutes. Still steaming, he told the story to one of the plant mechanics, who heartily agreed that the request was silly. "After all," said the mechanic, "nobody in the world could talk for 20 minutes on just 'gears'!"

Londoners beef about "pea soupers" while taking a dismal sort of pride in the undeniable superior density of local fogs. Now the Department of Scientific and Industrial Research backs them up by saying that in the year 1936–37 an average of 238 tons of soot fell on each square mile, and that domestic fires contributed slightly more than 2/3 of that sooty blanket. At that, they're better off than in 1915–16 when the average deposit amounted to 415 tons per square mile.

Gas from the sewage of a population of 480 will keep one brake hp running continuously, in a well-run sewage-disposal plant.

While a *Power* editor was looking over a plant in Washington, D. C., a maintenance man reported a water leak into one of the heating tunnels that smelled suspiciously like gasoline. Before he could object, one of the laborers established the fact that it was gasoline by the simple and direct expedient of lighting a match. Fortunately, no accumulation of vapor existed and the fire burned slowly and over a small area only. Draw your own moral.

One of Power's *gallivanting editors got a jolt recently when he saw a Wheeling, W. Va., stack blowing a perfect smoke ring every two or three seconds. After a hasty check on his behavior the night before, he decided that his vision wasn't playing him tricks. As for the reason, well, even editors get stumped.*

Fruits are now precooled before shipment by portable compressor units, diesel-powered, mounted on trucks. Such an outfit is driven up to a loading shed or loaded car, and cold air is pumped through the fruit, removing the "field" heat and effectively cooling the load. Less ice is consumed in transit since the load starts cool; the saving is substantial.

Power engineers aren't the only ones who have headaches, apparently. According to Monsanto Current Events, 5,000,000,000 aspirin tablets are consumed in this country in one year—close to 50 for each inhabitant.

Old Doc used to say we should drink lots of water in summer. Especially when working in hot places; engine and boiler rooms are seldom air-conditioned. The idea of the water is to supply makeup for that lost in sweat. New Doc adds another caution. Sweat contains salt, the ordinary table kind, and the body supply is reduced by sweat. It makes no difference how you get it, more heavily sprinkled on the lunch or salt tablets kept near the old oaken bucket; in any case, you've got to make up for the salt you lose.

Cooling Congress

Fair and cooler weather forecast for Capitol Hill. 4800-ton chilled-water system is largest comfort-cooling job on record. Four buildings are conditioned

THE WORLD'S largest comfort-cooling plant will begin operation this summer at the slightest rise in Congressional temperature. Not only the Capitol but Old and New House Office Buildings and Senate Office Building are now air-conditioned.

Although each of the buildings has its own finned-coil cooling units, fans and air washers, all the refrigerating effect, 4800 tons, is produced in the Capitol Power Plant, half a mile from the Capitol itself. Chilled water is distributed in a single pipeline circuit, the round trip to the Senate Office Building being about a mile and a half.

About 8000 gpm is pumped through the six evaporators into the supply header. At each building, part of this water, at 40 F, is taken off and circulated through the individual finned-coil units. The latter are so arranged that the chilled water flows in a closed circuit to the return header at about 54 F. Spray wash water for each air washer is a separate circuit so that the chilled water is not contaminated or exposed to air where it might pick up oxygen with possible corrosion effects.

The 24-in. pipeline is carried in tunnels beneath the streets and buildings. It is inside-painted with bitumastic and cork insulated outside. Due to the closed-circuit flow, scale and corrosion are no problem. No water treatment is used nor is it expected that the friction loss in the piping will increase appreciably even over a long period of years. Present total pumping head is about 300 ft. Flow from the power plant is held constant regardless of cooling load, water not called for by automatic control is bypassed to the return header, which is

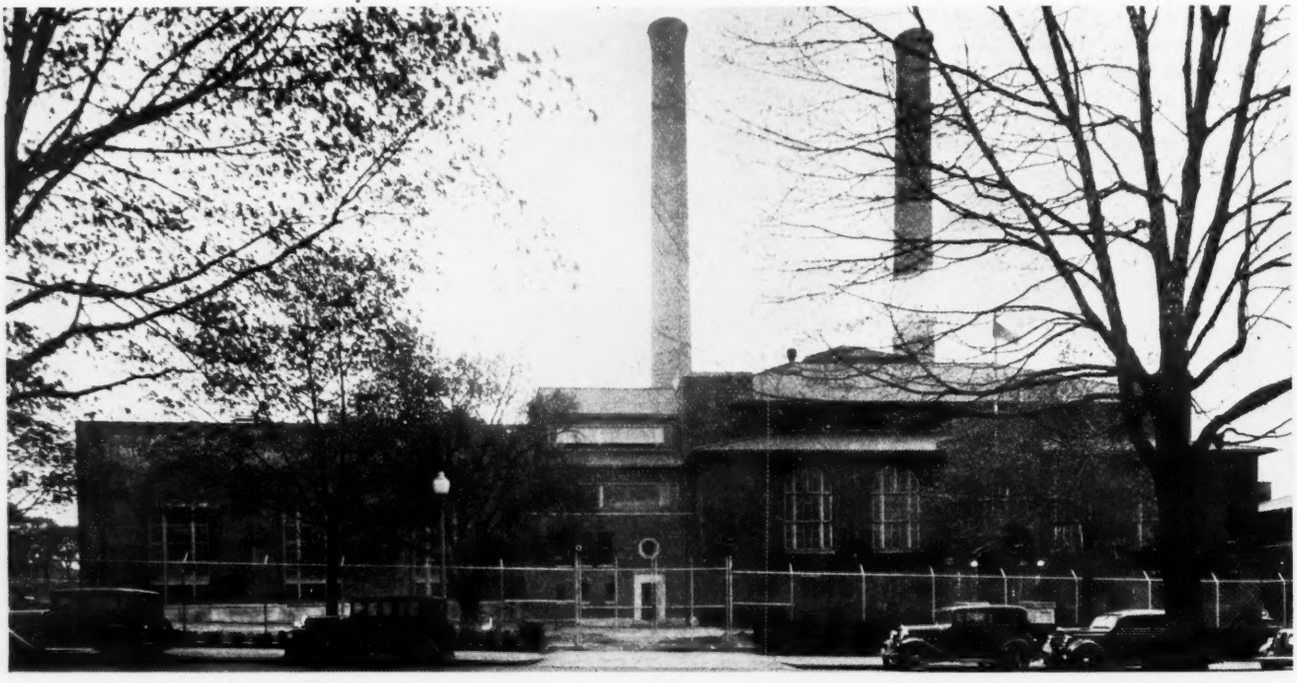


Fig. 1—Extension to Capitol Power Plant, at left in photo, is devoted exclusively to Freon units and their auxiliaries

an exceedingly simple arrangement.

The 120 x 78-ft extension to the Power Plant Building houses the six motor-driven Freon compressors and their associated equipment, evaporators, condensers and pumps. The 800-ton compressors are the largest reciprocating units yet built for Freon and, with their associated evaporators and condensers, represent latest design developments of the York Ice Machinery Corp. Completely assembled in the shop, transportation from railroad to power plant required a special beam trailer and combined efforts of District of Columbia Engineering Dept and Washington Police to minimize disturbance to busy downtown traffic.

A fair idea of the size and compactness of the installation may be had from the fact that the daily equivalent of the refrigerating effect is greater than that of a block of ice the size of the entire building extension which houses the equipment. Space is available for a future addition to the building which would house four more compressors to serve possible future loads.

Power Saving

Within the new structure, the 24-in. chilled-water line passes to the six evaporators in series, the water being cooled about 2 F in each. With equipment of this size, a considerable power saving is effected by operating the several compressors at different evaporator pressures. There is also the added advantage that a compressor can be put in or out of service without manipulating the 24-in. chilled-water valves, the water continuing to pass through the evaporator even when the compressor is not in operation. A bypass is provided as shown in Fig. 5, for maintenance or extended outage.

Two 4000- to 6000-gpm Ingersoll-Rand chilled-water pumps are driven by 800-hp Moore turbines. Either pump alone can handle about three-quarters of the usual flow. Condensing-water booster pumps and turbines are of the same manufacture and are located nearby. The drive turbines exhaust to two condensers, one chilled-water and one condensing-water turbine arranged in pairs connected to each condenser so that operation is not interrupted by outage of one condenser. A vacuum of about 25-in. Hg is maintained with river water temperature about 85 F.

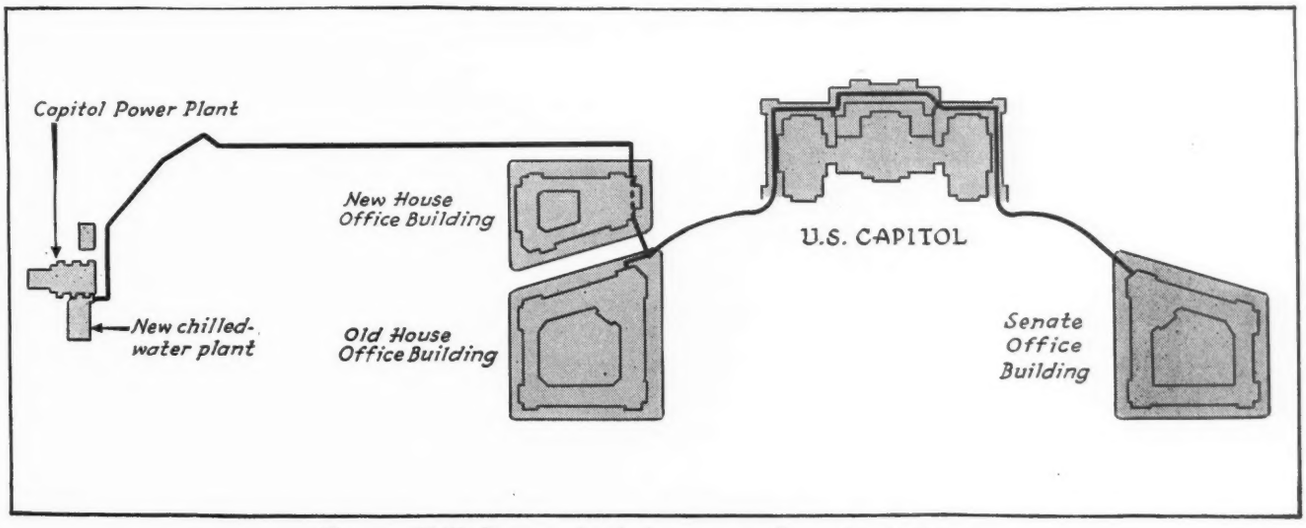


Fig. 2—Chilled-water circuit is over a mile and a half long

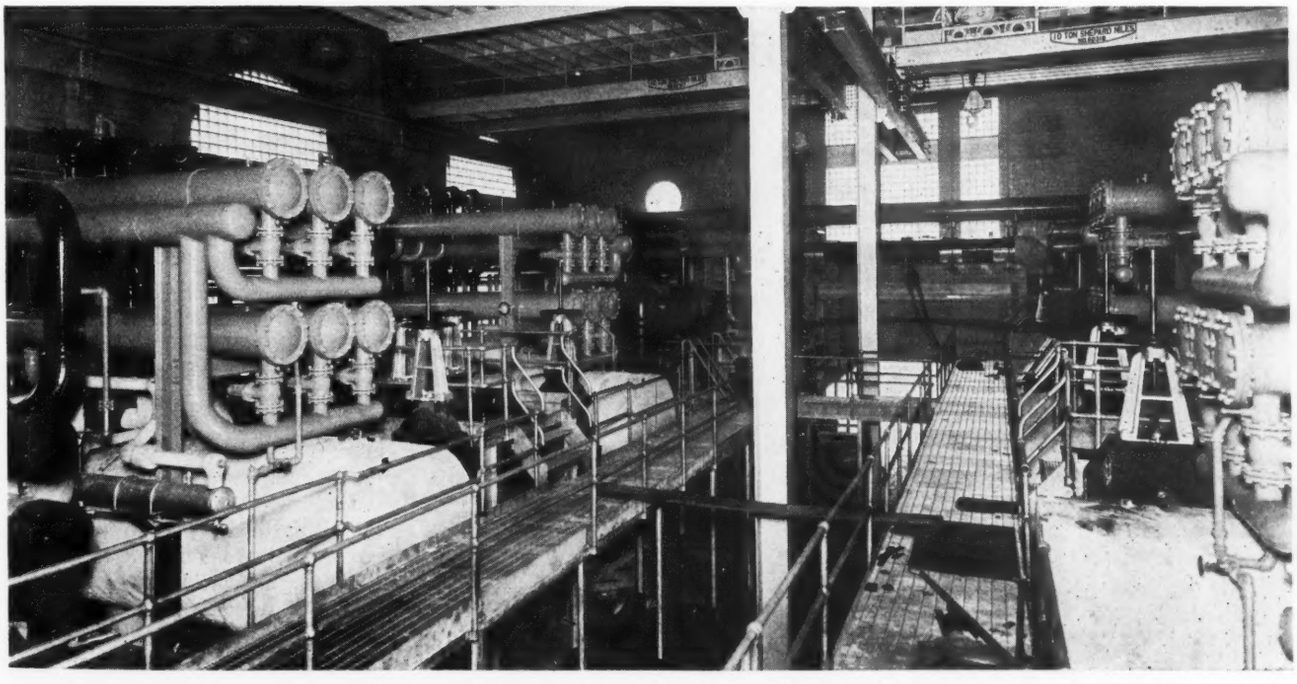


Fig. 3—Compactness is evident in equipment layout

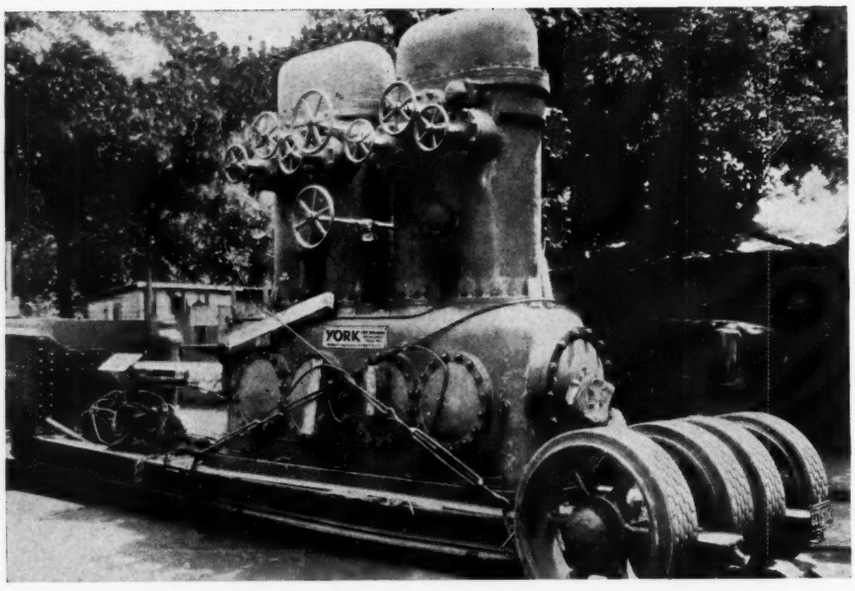


Fig. 4—One of the 800-ton York Freon compressors in transit

of one-pump operation. The Freon compressors are driven by 1000-hp, 6600-v, synchronous motors. Power supply is at 25 cycles from the plant's own generators. A 100-kw mg set supplies excitation for the motors.

Plans for the structure were completed prior to determination of the type of equipment which would be installed. Sufficient detail studies were made so that there would be no structural limitations imposed on manufacturers' equipment of special type. The actual installation of conditioning equipment was carried out under separate contracts for each of the various buildings and for the central refrigerating plant.

The project is under the general supervision of David Lynn, Architect of the Captol, and consulting engineers are Charles S Leopold of Philadelphia, Pa., and George A Weschler of Washington, D. C.

Circulating water for the Capitol Power Plant is pumped from the Anacostia River. Part of this supply is diverted by the refrigerating-plant booster pumps and circulated through the Freon condensers and the pump-drive condensers. Sufficient flow is provided to limit water-temperature rise to 10 F.

Pump Drives

Steam for pump-drive is obtained from the four bleeder turbines of the power plant at about 40 lb g. In winter this steam is used for building heating; in summer, of course, the plant heat balance is favorably affected by bleeding the main turbines to drive the pumps and a lower total electric load is imposed on the plant. Variable-speed drive on the pumps also allows greater capacity during periods

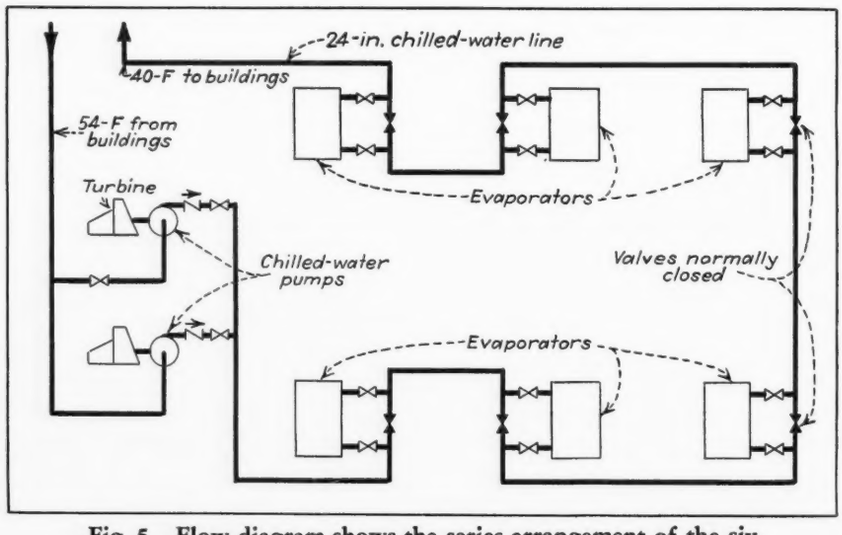


Fig. 5—Flow diagram shows the series arrangement of the six evaporators. No valve operation is required for load change

Why Not Use Pipe Standard

By SABIN CROCKER,* Detroit Edison Co

PIPE manufacturers and consumers both are penalized by not using the American Tentative Standard for Wrought-Iron and Wrought-Steel Pipe B36.10-1935, American Standards Association. If pipe for all ordinary applications were ordered from this standard, the greater ease in design and specification and decreased cost would benefit all interests.

This national standard was developed to: 1. Establish rational schedules of thickness. 2. Include thicknesses suitable for welding. 3. Provide suitable thicknesses for new processes and materials. 4. Eliminate unnecessary duplication. 5. Codify the various materials specifications.

The primary purpose is to reduce the large number of odd weights of pipe to a few standard commercial schedules of thickness, so that they can be secured from jobbers' stocks. This aim has not yet been realized due to unwillingness to abandon the obsolete terms "standard weight" and "extra strong," although most of these weights are included in the new schedules.

Lighter wall schedules than "standard weight" have been provided for economy in welded construction where the pipe is not weakened by threading. More of the lighter-weight pipe would be called for now if it were available from jobbers' stock. At the present time, it is impossible to secure these thicknesses from local jobbers with the result that Schedule 40 is often ordered when a lighter-weight pipe would serve.

Standardization will facilitate delivery, particularly on replacement orders, and avoid a costly mill set-up for producing a small quantity of pipe. More widespread acceptance of standard thicknesses in the alloy field is the only alternate to a hopeless complexity of special wall thicknesses with attendant high production costs.

*Secretary, Sectional Committee on Wrought-Iron and Wrought-Steel Pipe.

Clean Insulation

The system of periodic inspection and maintenance outlined in this article will eliminate the bugaboo of unexpected breakdowns

By R G STEPENSON
Service Division, Westinghouse Electric & Mfg Co

THE OWNER of a good watch knows that it must be cleaned and regulated regularly or it will not maintain correct time. The same is true of rotating electrical apparatus. Maintenance men should know that their job is not merely oiling bearings, dressing starter contacts or sanding and stoning commutators, but that periodic inspection and cleaning equipment is a most important function.

Periodic thorough cleaning of electrical equipment is the basic fundamental of economical operation. Dirt is one of the worst enemies of insulation, and as insulation is the vital spot of electrical apparatus, we must successfully combat this destructive agency if we are to cut down maintenance costs and lost time.

Experience Shows

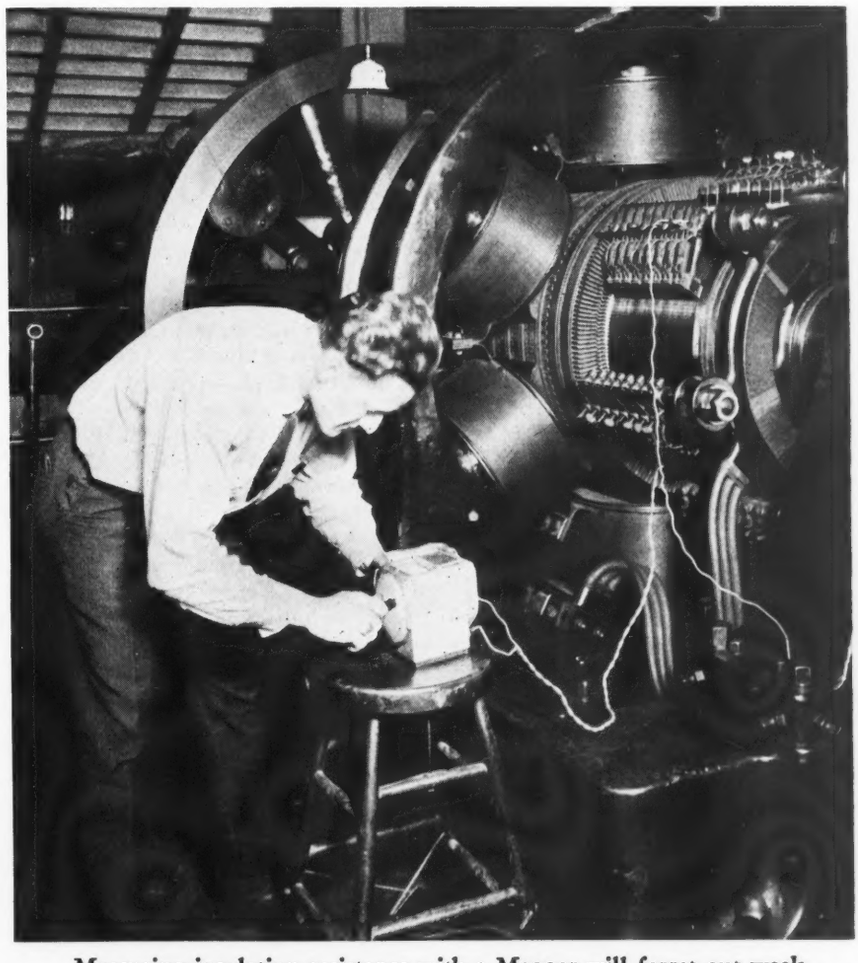
From experience, we know that the most likely breakdown point in a winding is where the coils emerge from the iron. The reason is not because of the laps or joints between the slot insulation and the diamond insulation, but deterioration of the once good insulation caused by accumulation of dirt at this point. Armatures burn out because dirt collects in and around the commutator necks and mica veerings. This dirt absorbs moisture and permits creepage currents that eventually carbonize the insulation and ground the commutator.

Now, how may we successfully combat dirt? Cleaning a motor is usually considered a menial task and too frequently is assigned to an apprentice or helper, without proper supervision. More harm than good can come of improper cleaning and, in some cases, motors and generators have burned out immediately upon being put back on the line.

A popular method of cleaning is to try blowing dirt out of motors with compressed air, using a suitable nozzle or brass tubing. Often, no provision is made to trap moisture from the air and the windings are sprayed with a fine mist. Then, there is the danger of shooting dirt into bearings, or blowing oil out of the oil-well. This method does not clean out the harmful dirt imbedded in cracks and crevices in the insulation, which is the dirt with which we are really concerned.

At least every two years or oftener, depending upon operating conditions, equipment should be dismantled and thoroughly cleaned. Wash all insulated parts with grease solvent. Most oil-refinery companies have on the market a product with a low flash point which will do the job and comply with health laws. A 50% solution of carbon tetrachloride and naphtha is a good cleaner, but may be injurious to health and creates a fire hazard.

After washing the winding, place it in an oven and heat to about 110 C for a while to bake out any moisture which might be present. Measuring the insulation resistance with a megger will show when the insulation has been thoroughly dried. Then while hot, dip in a cold vat of a good oil- and moisture-proof baking varnish. Bake in an oven heated to 110 or 120 C and leave for 8 hr. If the windings are old and dried out, repeat the dipping and baking operation. A megger reading should then indicate a higher reading, a proof of improvement.



Measuring insulation resistance with a Megger will ferret out weak spots in equipment before they have time to cause a breakdown

Give brush-holders attention. Wash all dirt and grime from them with the same solution used on the windings. See that tension springs and arms work freely and have sufficient tension. Carefully inspect the insulation to ground on the brush-holder arms. If brushes are worn, replace with a grade recommended by the manufacturer. See that they are the correct size and fit the brush-holder properly. Good commutation depends on the fit and grade of brushes.

Commutators are tricky things and must come in for a lion's share of attention. Clean well in and around the front vee-ring. Note if any of the bars are loosening. If they are, care must be used in tightening them—and tight they must be if you wish to avoid trouble. If it is determined that the commutator must be tightened, the following procedure is the safest and surest way to do it:

First, inspect to determine construction. Then, heat in an oven to about 100 C to soften the bond in the mica vee-ring so that a rupture or tear will not appear in the insulation when the commutator is drawn down. If no oven is available, wrap the commutator with a sheet of copper or a piece of galvanized iron and play a torch flame on it. This will prevent oxidation and softening of the copper bars. Heat evenly to prevent stresses. When hot, put in a press or between screw-down plates and draw the steel vee-ring into the vee. Do not use the commutator bolts or shaft nut to draw the rings down. Use external pressure to do the tightening and run down the nuts or studs to hold the vee-ring in place. When cold, carefully tap the bars to see if all are tight.

When tight and cold, place in a lathe and polish, undercut, and bevel all slots to make sure that no mica slivers remain in the slots to cause future trouble. Sand commutator to a nice polish and paint the exposed portion of the mica vee-ring with a good grade of red-oxide cement. On larger apparatus, recommended practice is to cord this exposed portion before painting.

Check Lubrication

Carefully inspect and clean all mechanical parts and check bearings for fit. See that all oil grooves in bearings are clear of babbit and that the oil rings turn freely and have no burrs or rough spots. Clean all oil and sludge from bearing wells and see that oil retainers are not worn down enough to allow dirt in and oil out. See that all passages are clear for free return of oil to prevent flooding. Look at shaft surfaces and oil-retaining grooves, and have them free of blemishes or dirt.

Reassemble motor, set brush-holders and brush tension by proper method. Check end play and see that shaft turns freely. Spray or paint outside of motor and see that the leads are protected by rubber bushings where they protrude through the frame. The motor is now ready to run and should be watched or checked frequently after starting until everything is functioning properly.

A periodic procedure such as this may seem unnecessary, but bear in mind that, even though a winding may not be dirty, insulation will become dry and cracked from vibration and needs a dipping or baking treatment just as much as a dirty winding. Even if facilities will not permit the dipping and baking process, substitution of a treatment with a good air drying plus oil- and moisture-proof varnish will give good results. The first commandment before any treatment is: *Clean and dry the windings thoroughly,* as varnish over dirt is of no value.

Finally, frequent close inspection will locate possible sources of trouble before it occurs and a Megger test of the winding will show the amount of reserve insulation in each motor or generator. Cleanliness should be the motto of each maintenance man and the decrease in maintenance costs and outages will convince the most skeptical equipment owner.

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Superheat to Save

By CHARLES L HUBBARD

AN ALL-YEAR-around heat wave has hit the power-plant field—high-temperature steam is a feature of new and modernized plants. The central stations and large industrial plants, well aware of the gains high temperature offers, have spent time and money to make its application practical. Thus the large number of plants using steam at the 850-900 F level. But how about the smaller, older plants? Are they to stand on the sidelines watching the parade, or can they join? The answer is that raising steam temperature offers real advantages to them as well; in most cases it offers an inexpensive step toward modernization.

With 100- to 125-F superheat, the steam consumption may be cut by as much as 40% for slow-running throttling engines and direct-acting steam pumps, 20% for simple non-condensing engines (medium piston speed) and compound direct-acting pumps, and about 10% for compound condensing engines with Corliss valve gear. It is customary to figure the saving in steam consumption due to raising the steam temperature at about 1% for every 10-F increase in superheat, for simple engines.

Superheated steam prevents undue moisture in the last stages of turbines. Moisture there means frictional resistance and windage losses which decrease efficiency, and blade erosion which means heavy maintenance. The actual effect of raising steam temperature on turbine operation depends, of course, on the size of the unit and the operating conditions, but for small impulse turbines, and for the first 150 F of superheat, every increase of 10- to 12-F will increase efficiency about 1% for non-condensing units, and every increase of 14 F will increase efficiency about 1% for condensing units.

The addition of superheating surface, of proper design, to a boiler tends to increase the boiler efficiency, since flue gas is cooled to a lower temperature. By the same token, raising the steam temperature means getting more heat units out of the same boiler, provided, of course, that there are no close limits on the amount of coal that can be successfully burned in the furnace.

In stepping-up steam temperature in an existing plant, take care not to exceed the safe working temperature for pipe, fittings, valves and prime-mover parts. Bear in mind that neither cast iron or bronze is satisfactory for service at temperatures over 500 F. At or around these temperatures, cast iron begins to "grow" and this extremely slow swelling weakens the material.

To be on the safe side, a temperature somewhat under 500 F should be regarded as the limit for existing plants in which temperature is to be raised without extensive alterations. This means that plants now operating at pressures up to 150 lb (saturated) may be made to carry 100- to 150-F superheat with safety. Before making such a change, however, equipment should be thoroughly checked to make sure it is sound.

POWER PUMPING

By F A ANNETT
Associate Editor

THE "HEART" of man's life-carrying stream, as well as of the mechanical units he produces, is the pump. Any man who knows pumps, with their accessory piping, valves and fittings*, is 50% a power engineer if he knows nothing else.

The pump is one of man's oldest aids. It provided water for Egypt, China, India, Greece and Rome. In 150 BC, Hero talked of a force pump designed by Ctesibius of Alexandria and of a peculiar toy that lifted water with air. The Germans had rectangular-barreled verticals in the 5th century; the rotary dates from the 16th; double-acting units were described as early as 1716; and Lemour outlined the principle of the centrifugal before the French Academy in 1732.

But England's steam pioneers wanted something more. Worcester built the first workable pumping engine for a water supply to Raglan Castle; then Savery, Newcomen and Watt labored to adapt it for pumping water from English coal mines. One after another, they worked throughout a century to achieve a real mechanical method of pumping. To succeed, they had to develop the steam engine and the boiler.

Even today, any boiler, any prime mover, any complicated machine, is helpless without the pump. Its applications are legion. These, coupled with its ancient lineage, have produced hundreds of designs and builders—approximately a thousand manufacturers in the United States alone. Materials range from cast iron and stoneware to solid gold, "fluids" pumped from ether and drinking water to thick mud or small solids, including the supreme corrosive, hydrofluoric acid, and one of the heaviest metals, molten lead. The smallest pump makes a dime look big, the largest takes over 60,000 hp to drive. Working head may be an inch or so of water or something over a mile.

To the lay mind, a pump is a simple thing—just a piston sliding back and forth in a cylinder, or a paddle wheel whirling inside a case. Yet certain pump problems are so difficult that even today, after more than 2000 years of development, experts devote their lives to pump design. Still, all is not known—for cavitation, erosion and plain poor operation annually take a tremendous toll.

From the very start of this series of special sections, the editors of *Power* have known that a treatise on pumps was eventually inevitable, and that properly handled, it could be made an outstanding service to all readers. The problems in preparing it have been great, but we felt that the need for it was greater. Any detail would take volumes, but we have tried to cover the main practical points in 16 pages. Its very brevity means that you can master the essential principles and facts with a few hours study. Those few hours are a cheap price to pay for the knowledge that will make you at least 50% a power engineer.

* "Fluid Highways", *Power*, December and Mid-December, 1937.

What Is Head on a Pump?

BEFORE purchasing a pump, the head against which it is to operate must be determined. This is of particular importance for centrifugal pumps, because a mistake in estimating the head may result in an unsatisfactory unit, or one that will fail to function. The total head under which a pump operates is made up of several elements, each of which must be considered.

Take for example the pump and piping layout, Fig. 1. The pump, in addition to lifting water through vertical distance from the suction well to where it will flow into the tank, must also overcome friction of pipe and fittings when delivering its rated capacity. Velocity head, entrance and exit losses must also be taken into account.

Total static head is the vertical distance from free surface of supply source to point of free discharge, Fig. 1, or to free surface of the liquid in the discharge well, Fig. 2. When both the suction and discharge are open to atmosphere, total static head is only a difference in elevation.

Static suction lift exists when the supply is below the pump center line, Fig. 1, and is the vertical distance from the free surface of the suction well to center line of the pump.

Static suction head, also known as head on suction, exists when the source of supply is above the center line, Fig. 3. It is the vertical distance from center line of pump to free surface of liquid in the supply source.

Dynamic suction lift, when it exists, is the static-suction lift, Fig. 1, plus entrance, velocity and friction losses (but not internal losses in the pump) when it is delivering full-rated capacity. Where static suction head exists, Fig. 3, but the sum of entrance, velocity and friction losses in the suction pipe exceed static suction head, we have a dynamic suction lift equal to the sum of the losses minus the static suction head. Thus, a pump may have a static suction head at partial load and a dynamic suction lift when delivering its rated capacity.

Dynamic suction head may exist when the surface of the supply source is above the center line of the pump, Fig. 3, and is the vertical distance from the free surface of supply to the pump center line minus entrance, velocity and friction losses (but not the pump's internal losses), when the pump is delivering its rated capacity. Dynamic suction head exists only when the sum of the entrance, velocity and friction losses is less than the static suction head.

Friction head is the equivalent head in feet necessary to overcome friction of the liquid on the interior surfaces of pipe and fittings, and varies with the character of the liquid being pumped, the condition of the pipe and fittings and kind of fittings.

Velocity head (when the water is moving at a given velocity) is the equivalent head (distance) in feet through which it would have to fall in a vacuum to attain that velocity. In other words, it is the head necessary to accelerate the water in the pipeline. It is sometimes referred to as the head due to velocity and may be obtained by the formula $h = \frac{V^2}{2g}$, where h is velocity head in feet, V water velocity in ft per sec, and g, acceleration due to gravity (32.2 ft per sec.).

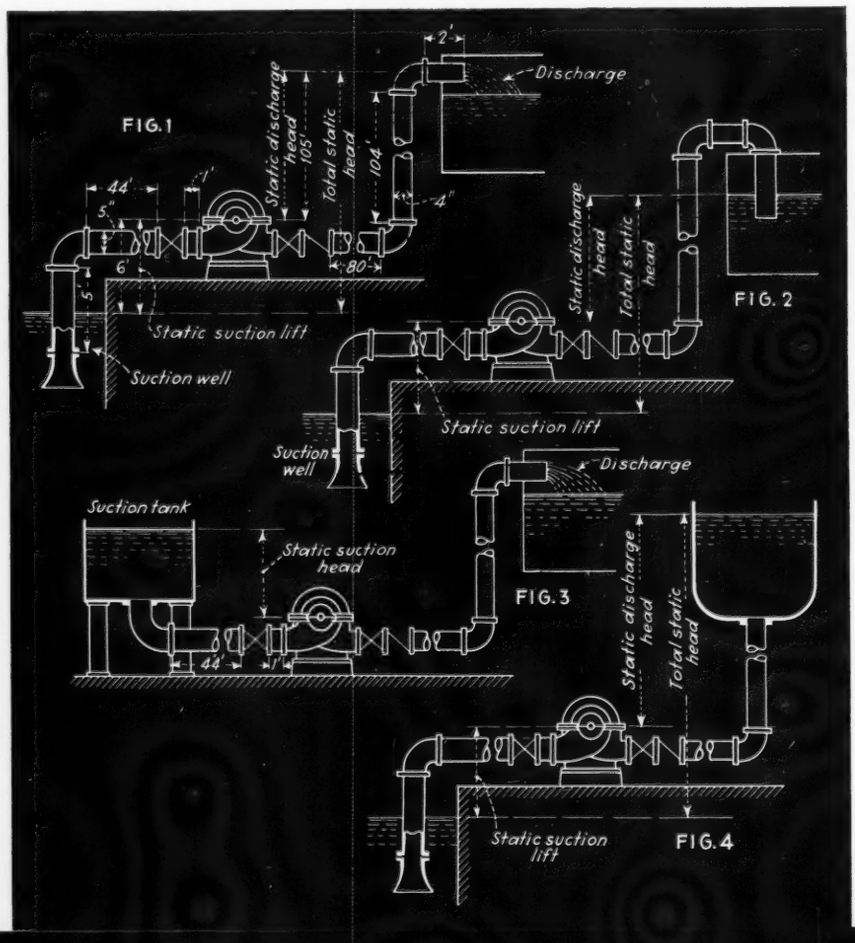
Static discharge head is the vertical distance from pump centerline to free surface of the liquid in the discharge well or to point of free discharge. Figs 1, 2 and 4 show static discharge head for three conditions.

Dynamic discharge head is the static discharge head plus the head necessary to overcome friction in the discharge piping plus the velocity head, the exit and velocity losses, when the pump is delivering its rated capacity.

Total dynamic head is the total head against which the pump must operate and is the sum of the dynamic suction lift and dynamic discharge head. Where dynamic suction head exists, total dynamic head equals dynamic discharge head minus dynamic suction head.

To make clear the practical use of

Figs. 1 to 4—Suction lift, suction head, static discharge head and total static head are measured as shown



Head Loss in Ft, Due to Water Friction, Per 100 Ft of 15-Year-Old Ordinary Iron Pipe

Gal. Per Min.	0.5-In. Pipe		0.75-In. Pipe		1-In. Pipe		1.25-In. Pipe		1.5-In. Pipe		2-In. Pipe		2.5-In. Pipe		3-In. Pipe		4-In. Pipe		5-In. Pipe		6-In. Pipe		7-In. Pipe		8-In. Pipe		10-In. Pipe		12-In. Pipe		14-In. Pipe		16-In. Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
1	1.05	2.1																														
2	2.10	7.4	1.20	1.9																												
3	3.16	15.8	1.80	4.1	1.12	1.26																										
4	4.21	27.0	2.41	7.0	1.49	2.14	0.86	0.57	0.63	0.26																						
5	5.26	41.0	3.01	10.5	1.86	3.25	1.07	0.84	0.79	0.40																						
10	10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	0.50																				
15			9.02	80.0	5.60	25.0	3.20	6.50	2.36	3.0	1.53	1.08	0.98	0.36																		
20			12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.2	2.04	1.82	1.31	0.61	0.91	0.25																
25					9.30	64.0	5.36	16.6	3.94	7.8	2.55	2.73	1.63	0.92	1.13	0.38																
30					11.15	89.0	6.43	23.5	4.72	11.0	3.06	3.84	1.96	1.29	1.36	0.54																
35					13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.1	2.29	1.72	1.59	0.71	0.89	0.17														
40					14.88	152.0	8.58	40.0	6.3	18.8	4.08	6.6	2.61	2.20	1.82	0.91	1.02	0.22														
45							9.65	50.0	7.08	23.2	4.60	8.2	2.94	2.80	2.05	1.15	1.15	0.28														
50							10.72	60.0	7.87	28.4	5.11	9.9	3.27	3.32	2.27	1.38	1.28	0.34														
70							15.01	113.0	11.02	53.0	7.15	18.4	4.58	6.21	3.18	2.57	1.79	0.63	1.14	0.21												
75									11.80	60.0	7.66	20.9	5.01	7.0	3.4	3.0	1.92	0.73	1.22	0.24												
100									15.74	102.0	10.21	35.8	6.54	12.0	4.54	4.96	2.55	1.23	1.63	0.41	1.14	0.14										
125									19.50	151	12.75	54.0	8.16	18.5	5.67	7.9	3.19	1.86	2.04	0.64	1.48	0.28										
150											15.32	76.0	9.80	25.8	6.8	10.5	3.84	2.55	2.45	0.88	1.71	0.32	1.25	0.17								
175											17.85	102.	11.3	33.5	7.94	14.0	4.45	3.44	2.86	1.18	2.00	0.48	1.45	0.23								
200											20.4	129.	13.07	43.1	9.08	17.8	5.11	4.40	3.27	1.48	2.28	0.62	1.66	0.28	1.28	0.15						
225													14.71	54.3	10.2	22.3	5.77	5.45	3.67	1.86	2.57	0.74	1.86	0.34	1.44	0.18						
250													16.3	66.0	11.32	27.2	6.40	6.72	4.08	2.24	2.80	0.92	2.07	0.42	1.60	0.22						
275															12.50	32.5	7.03	7.99	4.50	2.72	3.06	1.15	2.30	0.51	1.73	0.27						
300															13.62	38.0	7.66	9.30	4.90	3.14	3.40	1.29	2.49	0.60	1.90	0.32						
350																	8.90	12.32	5.72	4.19	3.98	1.75	2.95	0.80	2.20	0.42						
400																	10.21	16.00	6.54	5.40	4.54	2.21	3.36	1.03	2.60	0.54						
450																	11.50	19.80	7.35	6.70	5.12	2.65	3.75	1.25	2.92	0.68	1.80	0.21				
475																	12.20	22.96	7.76	7.42	5.55	2.95	4.43	1.72	3.10	0.76	1.94	0.25				
500																	12.77	24.00	8.17	8.12	5.60	3.30	4.14	1.64	3.20	0.82	2.04	0.28	1.42	0.11		
G P M																																
550																	14.04	28.7	8.99	9.60	6.16	3.93	4.55	1.81	3.52	0.97	2.25	0.33	1.57	0.14		
600																			9.80	11.30	6.72	4.70	4.97	2.09	3.84	1.14	2.45	0.39	1.71	0.15		
650																			10.62	13.20	7.28	5.40	5.39	2.45	4.16	1.34	2.66	0.46	1.85	0.19	1.37	0.09
700																			11.44	15.10	7.84	6.20	5.80	2.83	4.46	1.54	2.86	0.52	2.00	0.22	1.47	0.10
750																			12.26	17.20	8.50	7.00	6.21	3.21	4.80	1.74	3.06	0.59	2.13	0.24	1.58	0.11
800																			13.07	19.40	9.08	8.00	6.62	3.58	5.12	1.97	3.28	0.67	2.27	0.27	1.68	0.13
850																			13.89	21.7	9.58	8.95	7.04	4.06	5.48	2.28	3.48	0.75	2.41	0.31	1.79	0.14
900																			14.71	24.00	10.30	10.11	7.46	4.54	5.75	2.46	3.68	0.83	2.56	0.34	1.89	0.16
950																					10.72	10.80	7.88	5.02	6.06	2.87	3.88	0.91	2.70	0.38	2.00	0.18
1,000																					11.32	12.04	8.28	5.5	6.40	3.02	4.08	1.01	2.84	0.41	2.10	0.19
1,050																					11.90	13.30	8.47	5.76	6.70	3.21	4.29	1.09	2.98	0.44	2.20	0.22
1,100																					12.50	14.31	8.69	6.04	7.03	3.51	4.50	1.20	3.13	0.49	2.31	0.23
1,150																					12.95	15.60	9.31	6.36	7.35	3.84	4.71	1.34	3.27	0.53	2.42	0.25
1,200																					13.52	16.69	9.93	7.69	7.67	4.15	4.91	1.46	3.41	0.57	2.52	0.26
1,250																					14.10	18.50	11.22	9.62	8.00	4.45	5.11	1.55	3.55	0.62	2.63	0.29	1.99	0.15
1,500																					17.02	25.60	12.42	11.65	9.60	6.27	6.10	2.09	4.20	0.85	3.15	0.39	2.39	0.21
2,000																							16.56	19.92	12.70	10.71	8.10	3.65	5.60	1.43	4.20	0.66	3.19	0.39
2,500																									15.80	15.15	10.10	5.33	7.00	2.28	5.25	1.01	3.99	0.58
3,000																											12.10	7.80	8.40	3.15	6.30	1.47	4.79	0.80
3,500																											14.10	10.08	9.80	4.10	7.35	1.81	5.59	1.04
4,000																													11.35	5.32	8.40	2.47	6.38	1.34
4,500																													12.78	6.90	9.45	3.22	7.20	1.65
5,000																													14.20	8.40	10.50	3.92	7.96	2.02
5,500																															11.55	4.65	8.78	2.39
6,000																															12.60	5.50	9.56	2.60
6,500																															13.65	6.45	10.36	3.32

Vel. = Water velocity in pipe in feet per second

Fric. = Feet head loss due to pipe friction

Friction loss values based on Williams & Hazens formula;

$$S = \left\{ \frac{V}{1.318\ CR^{0.63}} \right\}^{1.85}$$

Where S = Friction loss in feet head per foot of pipe.

V = Flow velocity in feet per second.

C = Constant depending on condition and kind of pipe. In the table, C = 100.

H = Hydraulic radius of pipe = pipe inside diameter in feet ÷ 4.

Example—A flow of 100 gpm in a 2-in. pipe produced a velocity of 10.21 ft per sec and a head loss of 35.8 ft.

Feet of Straight Pipe to Which Fittings are Equivalent

Diam. Inches	Standard Elbow	Long-Radius Elbow	Globe Valve	Gate Valve
0.5	1	0.5	3	0.4
0.75	1.5	0.75	5	0.6
1	2	1.2	6	0.8
1.25	3	1.5	9	1.2
1.5	4	2	11	1.5
2	5	2.5	14	2
2.5	6	3	18	2.8
3	8	4	24	3
4	11	5.5	32	4.2
5	15	7	42	5.5
6	18	9	52	7
7	20	10	60	8
8	24	13	75	10
10	32	16	100	13
12	40	20	125	16
14	48	24	150	19
16	58	29	175	22

Example:—Head loss through a standard 2 in. elbow is equivalent to 5 ft., a long-radius elbow to 2.5 ft., a globe valve to 14 ft., and a gate valve to 2 ft. of straight pipe.

Data for Estimating Purposes

1. Kind of service: Continuous or intermittent. No. of pumps required.....
2. Capacity — U.S. gpm... Kind of liquid... Temp. F... Specific gravity...
3. Static disch. head..Ft. (Vert. dist. from pump center to point free discharge)
   Dia. pipe.. Length.. No. elbows: 90 deg..45 deg.. No. and type of valves..
4. Static suction lift.....Ft. (Exists when supply is below center of pump. Vert. dist. from pump center down to level source of supply)
   Dia. pipe.. Length.. No. elbows: 90 deg..45 deg.. No. and type of valves..
   Or static suction head..... Ft. (Exists when supply is above pump center. Vert. dist. from pump center up to level of supply source)
   Variation in suction lift or suction head, ft.....
5. Type of drive desired... Are we to furnish... If belted... Hp of driver...
   Speed.. Dia. driving pulley.. If motor drive, direct or alternating current:
   Voltage..... Cycles..... Phase..... Type of control.....
   If turbine drive: Steam pressure.. Superheat.: Backpressure or in. vacuum..
   If you have driver available, give full rating.....
6. Remarks and special conditions not covered above.....

these definitions, consider the problem of determining the head for selecting the pump of Fig. 1. The pump is assumed to have a 5-in. suction, a 4-in. discharge and a capacity of 500 gpm. Pump centerline is 6 ft above suction-well water level and 105 ft below center of discharge into the tank. This gives a total static head of 6 + 105 = 111 ft. But the pump must also produce sufficient head to overcome losses in piping and fittings in addition to the static lift.

Calculating Losses

The suction pipe includes an intake bell, 5 ft of vertical pipe, a 90-deg long-radius elbow, a gate valve and 45 ft of horizontal pipe. The intake-bell loss is so small that it can be neglected. To calculate the loss in pipe and fitting, it is necessary to know the water velocity in them. This can be found in the table or it may be estimated from the formula $V = Q \div A$, where V equals water velocity in ft, Q the water quantity in cu ft per sec, and A area of pipe cross section in sq ft. Calling pipe diameter in inches, D, then area $A = (D \div 12)^2 \times 0.7854 = 0.136$ sq ft. Quantity Q = gpm $\div$ 450 = 1.11 cu ft per sec. Velocity $V = 1.11 \div 0.136 = 8.17$ ft per sec, the same as given in the table. As previously shown, velocity head $h = V^2 \div 2g = (8.17 \times 8.17) \div (2 \times 32.2) = 1$ ft. Except for very low heads, velocity head can be neglected.

Total length of straight pipe in the suction line is 6 + 44 + 1 = 51 ft. A 5-in., 90-deg long-radius elbow as shown in the table is equivalent to 7 ft, and 5-in. gate valve to 5.5 ft, say 6 ft of straight pipe. This gives the suction pipe an equivalent length of 51 + 7 + 6 = 64 ft. The table gives a head loss of 8.12 ft per 100 ft of 5-in. pipe with 500-gpm flow. Then, in 64 ft, head loss will be (8.12 $\div$ 100) $\times$ 64 = 5.2 ft. Total suction head equals static head plus friction head, equals 6 + 5.2 = 11.2 ft. This is the dynamic suction head, and is head against which water must be lifted to flow into the pump.

Discharge Head

On the discharge side of the pump, the line comprises a gate valve, a check valve, 80 ft of horizontal pipe, a 90-deg long-radius elbow, 104 ft of vertical straight pipe, a 90-deg long-radius elbow and 2 ft of horizontal pipe going in the tank, all 4 in. in diameter. The gate valve is equal to 4 ft of straight pipe, the check valve can be taken as equivalent to a globe valve or equivalent to 32 ft of straight pipe and the 90-deg bends to 5.5 ft. each. This makes the equivalent length of discharge pipe equal to 4 + 32 + 80 + 5.5 + 104 + 5.5 + 2 = 233 ft. The table gives the head loss in 100 ft of 4-in. pipe with 500 gpm flow as 12.77 ft. Then total head loss is (12.77 $\div$ 100) $\times$ 233 = 29.75, say 30 ft, which makes the dynamic discharge head 105 + 30 = 135 ft. The total head against which the pump must operate equals the sum of the suction dynamic lift plus the dynamic discharge head or 12 + 135 = 147 ft total dynamic head. Therefore, select a pump that will discharge 500 gpm against 147 ft, say 150-ft head.

Estimating the head against which a pump will operate is not an exact calculation because the quantities dealt with vary over quite a wide range. Fitting losses vary with design and construction. Condition of the pipe's internal surface is not only changing but its diameter is frequently decreased by scale deposits. About the best that can be done is to estimate the head as carefully as possible, leaning a little towards the safe side. Then, if our estimates are a little high, the pump will have a higher discharge than rated. This is not objectionable, as in time, changed conditions in the pipe and fittings will probably increase the head.

The suction- and discharge-pipe size should be liberal and an economic study will no doubt show that a 5-in. or even 6-in. pipe is more economical than the sizes used in the problem, Fig. 1. To select most economical size of pipe see "How Big a Pipe for Your Pump?" and "Use Larger Pipes to Reduce Pumping Costs," by Frank A Kristal, in *Power* for May and August, 1936.

Water Above Pump Suction

If the source of water supply is above the pump suction, as in Fig. 3, another problem is presented. Assume that the surface of the water in the suction tank will not drop lower than 7 ft above pump centerline. The friction-head loss will be that in 45 ft of pipe, a gate valve and a 90-deg bend, or the equivalent of 45 + 7 + 6 = 58 ft of straight pipe, which will have a head loss of (8.12 $\div$ 100) $\times$ 58 = 5 ft. Then the dynamic suction head will be 7 — 5 = 2 ft, which may be deducted from the dynamic discharge head to obtain the total dynamic head or 135 — 2 = 133 ft, for which the pump would be selected.

Water Horsepower

Power represented by the rate at which a pump discharges and total dynamic head against which it operates is called water horsepower (Whp) and is found by the formula: $Whp = (Gpm \times H \times S) \div 3960$, where H is total dynamic head in feet and S specific gravity of the liquid pumped, which for water is 1. In the problem, Fig. 1, water horsepower of the pump is: $Whp = (500 \times 150 \times 1) \div 3960 = 18.9$.

Horsepower required to drive the pump is: $Hp = (Gpm \times H \times S) \div (3960 \times \text{Eff.})$. If the pump has an efficiency of 0.75 when handling water, then power to drive it equals: $Hp = (500 \times 150 \times 1) \div (3960 \times 0.75) = 25.3$.

Efficiency of a pump expressed as a percentage equals its water horsepower output divided by the horsepower input times 100, thus (18.9 $\div$ 25.3) $\times$ 100 = 75%.

When ordering pumps, certain information should be given to the manufacturer so that he can supply a unit suited to your requirements. The form on this page includes most of the necessary items. Any special conditions should also be given.

Rotary Pumps

ROTARY PUMPS combine the constant-discharge characteristic of the centrifugal types with the positive-discharge feature of the reciprocating pumps. Some of the most widely used types of rotary pumps are two external spur gears, two spiral gears, two herringbone gears, external-internal gears, screw types, swinging vane, 2-lobe, 3-lobe or cam types, special-lobe types, guided-vane types and cam-and-piston types.

Fig. 1 shows a gear-type pump. The gears rotate in the direction of the arrows and have very close clearances with the casing. Where the gear teeth contact, they also form a fluid-tight joint. When the pump is primed, liquid flows in between the gear teeth, on the suction side. As the gears rotate, fluid is trapped between their teeth and the casing, and is carried around to the discharge. Since the liquid cannot escape back to the suction, a pressure is built up to force it out the discharge pipe.

Spur-Gear Pumps

Spur-gear pumps are intended for slow-speed operation up to about 600 rpm and for handling fuel oil, lubricating oil or other thick and viscous liquids that have lubricating qualities. Herringbone-gear pumps are designed for speeds up to 1800 rpm and for pressures up to 1500 lb per sq in.

A somewhat different design is the internal-gear type, Fig. 2. The rotor of this pump carries on its outer periphery what might be considered a gear, the teeth *T* of which are supported at one end on the rotor disk. This rotor revolves concentrically in the casing. Supported off center with the rotor is a free-running gear *G* which meshes with and is driven by the rotor gear teeth. A crescent *C* supported from the end cover of the pump insures a seal between the suction and discharge.

With the rotor turning in a counterclockwise direction by the intake, the teeth of gear *G* are withdrawn from between the rotor teeth. This action is similar to a piston on the suction stroke of a reciprocating pump and fluid flows in to fill the space between the teeth. As the rotor continues to turn, fluid is trapped between the teeth, crescent and casing and is carried around and forced out the discharge by the internal gear teeth meshing with those on the rotor.

Other designs of internal-gear pumps have one tooth less in the idler gear than in the driving gear. The idler is set off center so that it meshes with the driving gear on one side and makes a sealing clearance between the ends of the teeth of the two gears on the other, making the crescent in Fig. 2 unnecessary.

Lobe Pumps

Several designs of lobe-type rotary pumps have been developed. These are usually 2- or 3-lobe and are the equivalent of 2- or 3-tooth gears. Fig. 5 shows a 3-lobe type. Rotary pumps operate like gear pumps, except that fluid is delivered to the discharge in a smaller number of larger quantities.

The screw pump, Fig. 4, comprises a power rotor, to which the power source is directly connected. Two idler rotors act as seals to the power rotor and are driven by fluid pressure and not by metallic contact with the rotor. Fluid coming in from the suction to the two ends of the rotor is trapped in pockets formed by the threads and carried towards the discharge very much like a nut would be on the power screw. Handling oil, these pumps will operate at pressures up to 500 lb per sq in. and speeds up to 7000 rpm.

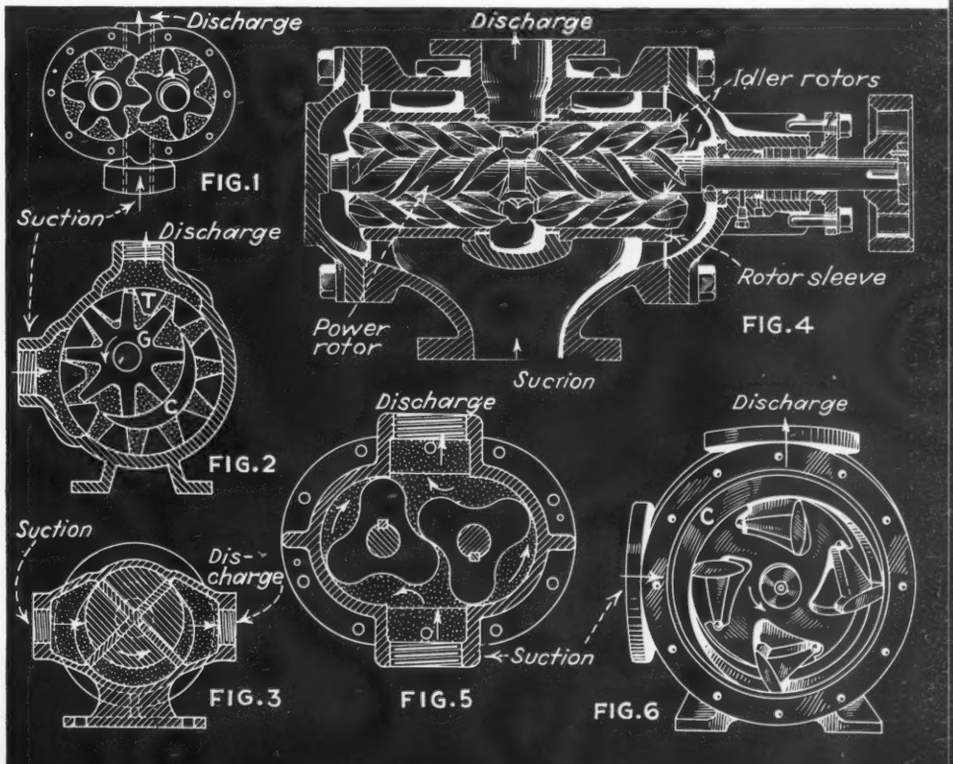
Several types of sliding-vane pumps have been developed, a cross section of one being shown in Fig. 3. The vanes are free to move radially through the rotor, which is set off center with the casing. When the rotor turns counterclockwise, fluid flowing in between its lower side and casing is trapped by vanes and forced out the discharge.

Swinging-Vane Pump

In the swinging-vane pump, Fig. 6, the rotor has four arms that support swinging vanes. The rotor is smaller than the bore of the casing, but one side is closed with a crescent *C*. This crescent is solid between the intake and discharge and, with the rotor arms, acts as a seal between the two. As the rotor turns, fluid flows from the intake into the space between the arms. Then, as the swinging vanes pass the intake opening, they are thrown out by centrifugal force and trap the fluid, which is carried around and forced out the discharge in much the same way as in the sliding-vane type.

Rotary-pump design permits applications where high vacuums are required up to within 1 in. of barometric. These pumps have been developed to cover all pressures up to 2000 lb per sq in. and in capacities up to 35,000 gpm under low heads. They are used for handling oil and a wide variety of materials free from abrasives.

Types of rotary pumps: Fig. 1—Spur-gear. Fig. 2—Internal-gear. Fig. 3—Sliding-vane. Fig. 4—Screw. Fig. 5—Three-lobe. Fig. 6—Swinging-vane



Centrifugal Pumps

CENTRIFUGAL PUMPS, as the name implies, employ centrifugal force to lift liquids from a lower to a higher level. This type of pump in its simplest form comprises an impeller rotating in a volute casing, Fig. 1. Liquid led into the center of the impeller is picked up by the vanes and accelerated to a high velocity by rotation of the impeller and discharged by centrifugal force into the casing and out the discharge.

Because of their simplicity, low cost and ability to operate under a wide variety of conditions, centrifugal pumps are popular. They are adapted to operate under practically any head up to 5000 ft or higher, will handle liquids at most any temperature up to 900 F, and operate at speeds that are standard for electric motors and turbines.

These pumps may be classified as volute-type, single-stage and multi-stage; diffuser-type, single-stage and multi-stage; peripheral turbine; and propeller or axial-flow types. In the volute pump, the impeller discharges into a progressively expanding spiral casing, as in Fig. 2. This casing is so proportioned as to reduce gradually velocity of the water as it flows from the impeller to the discharge, thus changing velocity head into pressure head.

Diffuser Pumps

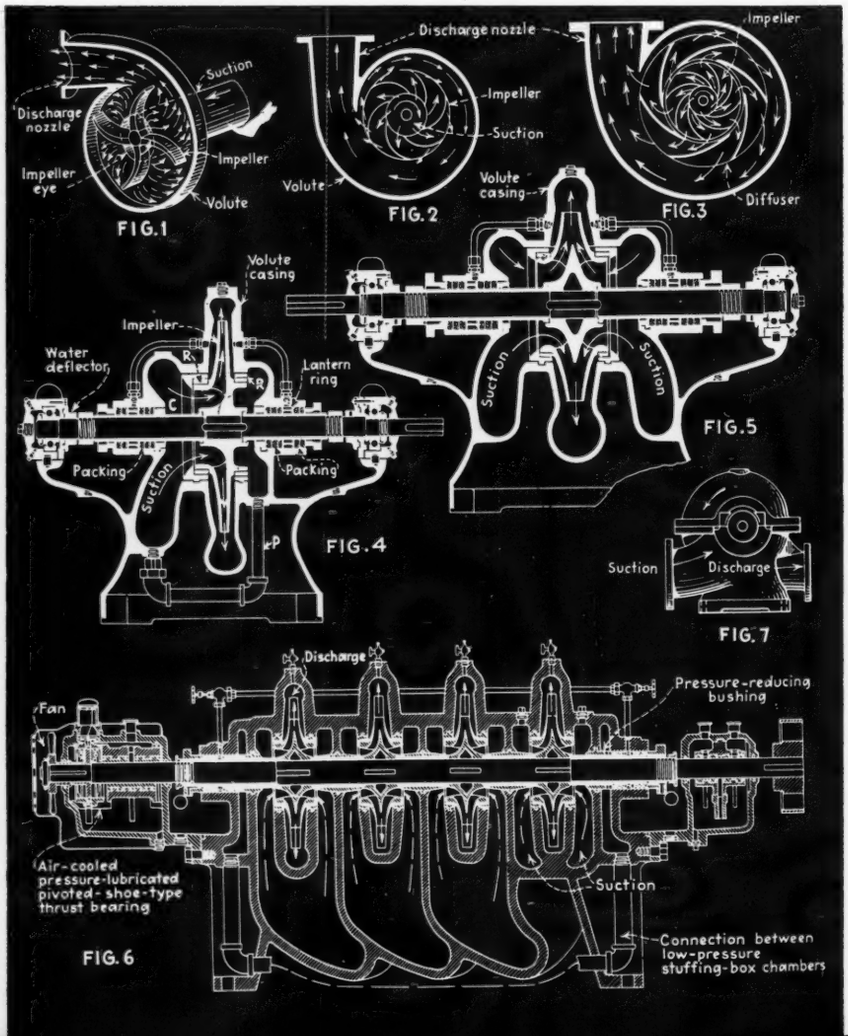
The runner of the diffuser-type pump is surrounded by gradually expanding passages formed by stationary guide vanes, Fig. 3. In these expanding passages, direction of flow is changed and velocity head converted to pressure head before the water enters the volute. This design of pump is sometimes referred to as a turbine pump, since its construction is similar to a hydraulic turbine, but operates the reverse. The turbine pump described later differs in principle and construction from that in Fig. 3.

Centrifugal pumps are built with a great many arrangements of impellers and other details of construction. One of the simplest-forms is the single-suction, single-stage design, Fig. 4. The impeller is of the closed type, that is, the vanes are supported between two disks so as to form closed passages between them. In Fig. 4, fluid from the suction line enters a chamber *C* that completely surrounds the intake of the impeller. As the fluid flows into the impeller, it is picked up by the impeller vanes and discharged into the volute and out the discharge at whatever head the pump may be working against.

This pump has several features common to many centrifugal pumps. The impeller (bronze) is keyed to the shaft. From each side of the impeller hub a bronze sleeve extends to the pump exterior and is held in place by a bronze nut. These sleeves protect the shaft from the liquid being pumped as well as wear from packing in the stuffing boxes.

On the inside of the stuffing box is a brass-packing retaining ring against which the packing rests. The packing consists of three rings of square cross-section, then a grooved brass ring, known as the lantern ring, followed by two more rings of square packing held in place by a bronze gland. The lantern rings are connected by pipe into the side of the volute and are therefore subjected to water pressure. This water serves the double purpose of lubricating the packing and forming a seal to prevent air leaking into the suction chamber.

Removable sealing rings at *R* minimize leakage from discharge into suction. When these rings wear they may be replaced to restore clearance and pump efficiency to their original values. Any leakage into the right-hand side of the impeller is taken back



Figs. 1 and 2—Flow in volute-type pump. Fig. 3—Flow in diffuser-type pump. Fig. 4—Single-stage single-suction pump. Fig. 5—Double-suction single-stage pump. Fig. 6—Four-stage double-suction pump. Fig. 7—Horizontally split casing

into the suction through pipe *P*. This arrangement maintains suction pressure on both stuffing boxes. With single-suction impellers, because of unbalanced hydraulic forces, there is always a thrust along the shaft. In the pump, Fig. 4, this thrust is taken by the deep-grooved ball bearings, made of ample size for axial thrust load as well as the radial load of the runner.

Single-Unit Pumps

A trend with single-stage single-suction pumps is to combine pump and driving motor into a single unit. The motor is built with a special extended shaft and with a special end shield so that the pump can be assembled right on the motor. This type of unit makes a rugged, compact, efficient pumping unit requiring a minimum of space and alignment checking. Multi-stage pumps of this design are also available.

Many pumps are of the double-suction type, Fig. 5, which is practically the same as Fig. 4, except that its runner is similar to two single-suction runners placed back to back. A suction chamber at each end of the impeller connects to a common suction pipe.

When sufficient head cannot be developed in one stage, multi-stage pumps are used. These have two or more stages in series, depending upon the head required. Fig. 6 shows a 4-stage double-suction runner pump. Liquid enters the runner on the right and is discharged into a spiral volute whence it flows through a long diffuser nozzle and return bend to the next stage on the left.

Flow from one stage to the next may be followed easily by the arrows. Multi-stage pumps have been developed in a great many forms. For a more complete discussion of these designs see "Boiler Feed Pumps," page 62, February 1937, *Power*.

The pumps, Figs. 4, 5 and 6, have their casings split along the horizontal center line, as in Fig. 7, a design common to many makes of centrifugal pumps. It makes easy internal inspection and removal of the rotor as a unit. How the suction leads into the center of the pump and the discharge connection comes out of the volute is clearly indicated.

Centrifugal pumps are manufactured in a great many forms and from all kinds of material, depending upon service. One of these is the non-clogging pump, generally built with the suction pipe coming directly into the eye of the impeller, Fig. 8. The eye and passages through the runner are made large to permit free flow. Some of these designs use a closed runner as in Fig. 8, but others have runners like the warped-vane type, Fig. 9, or the semi-open type, Fig. 10. Such pumps are used for handling paper stock, sewage, etc.

Pumps are made of or lined with almost every kind of material. The standards of the Hydraulic Institute, 90 West St, New York, N. Y., list five pages of material from which pumps are made and the services in which they are used. For handling sand, ashes and other abrasive materials, one line of pumps is made of manganese steel. Another has a casing lined with rubber and its rotor covered with the same material. For handling certain kinds of acids and other corrosive liquids, pumps may be made of monel metal, lead, hard rubber, stoneware, glass, etc. One design, for handling acids or hot solutions, that would cause stuffing-box troubles, and for handling sand and other abrasive solutions, is built without a stuffing box.

Fig. 11 shows the rotor for another form of centrifugal pump known as the turbine type. The suction connection comes to the periphery of the impeller instead of to the center as for the conventional centrifugal type. Liquid from the suction nozzle first comes in contact with the bottom of the impeller vanes. As the liquid is carried around in the pump channel it is caused to recirculate through the vanes as in Fig. 12, thus producing a multi-stage effect in a single stage. These pumps are built in the smaller size and for heads up to 350 ft.

Propeller Pumps

For heads under 40 ft and capacities above 300 gpm—as in drainage, sewage disposal, storm-water disposal, irrigation and similar services—propeller-type pumps have come into quite general use. These have an impeller similar to the propeller of a ship. One design is shown in Fig. 13. Axial-flow pumps are of a propeller type, but are arranged so that flow through the pump is practically parallel with the shaft, Fig. 14. The liquid first flows axially into the eye of the impeller and is forced along parallel with the pump shaft by action of the impeller vanes.

If it were posible to assign each type of pump to a particular field, the problem of proper selection would be fairly simple. Fields of application overlap and in many cases the final choice is a matter of individual preference on the part of the engineer or is dictated by local conditions. Where steam is available, and the exhaust can be used for heating or processing, steam pumps may prove to be the most economical, where otherwise the selection would be a centrifugal or a rotary type.

Centrifugal pumps may be very efficient; large, well designed pumps have an efficiency of over 90%. Small acid-handling pumps may have an efficiency of around 8 or 10%. But here efficiency is of secondary consideration, the primary object being to get a pump that will stand up under operating conditions and handle the liquids.

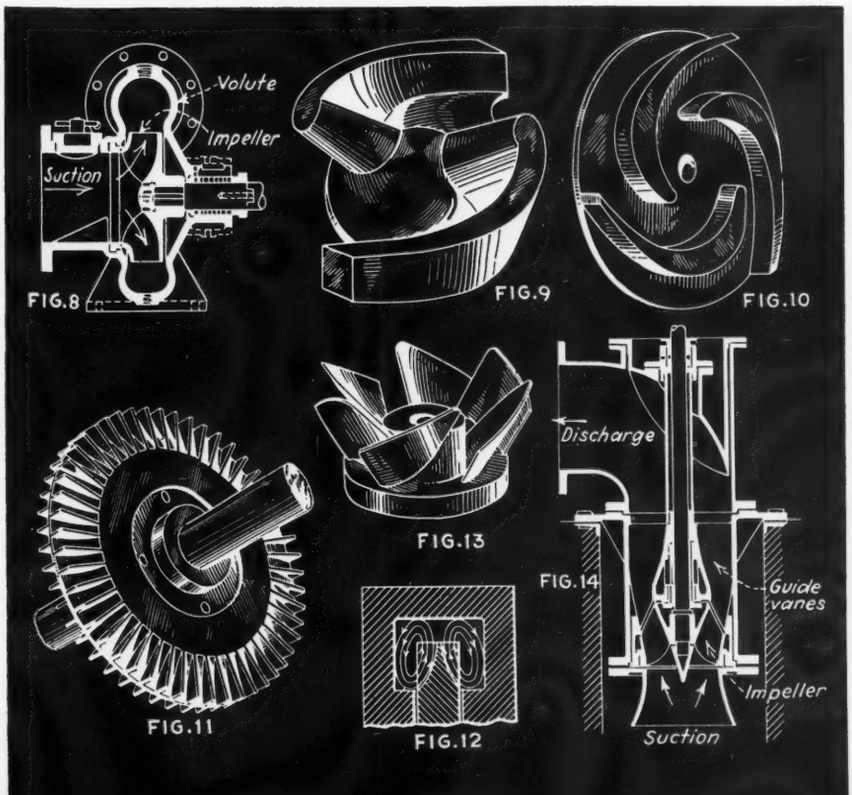


Fig. 8—Non-clogging pump. Fig. 9—Warped-vane runner. Fig. 10—Semi-open impeller. Fig. 11—Turbine-type impeller. Fig. 12—Flow in a turbine impeller. Fig. 13—Propeller-type impeller. Fig. 14—Section through axial-flow pump

Reciprocating Pumps

STEAM - DRIVEN reciprocating pumps may be classified as direct-acting simplex and duplex, and heavy-duty types in which a crank with a flywheel connects the pump to a steam engine. Power, motor-driven reciprocating pumps may be of three general types: simplex, duplex and triplex. These designs may be further classified as single-acting, double-acting, piston and plunger types, inside and outside packed, and other divisions.

A direct-acting steam-driven reciprocating pump is one in which the steam piston is directly connected to the liquid piston or plunger through a piston rod, Fig. 1. The steam end of this pump is similar to the conventional slide-valve engine, but other types of steam ends are used. There are two general types of these pumps, simplex and the duplex. The simplex has one steam and one water cylinder while the duplex pump has two duplicate steam and water cylinders, Fig. 1 being one-half of a duplex pump.

Piston Pumps

Reciprocating pumps may be either piston type, Fig. 1, or plunger type. In the piston pump, a piston moves in a cylinder as the piston does on the steam end. When liquids of poor lubricating qualities are handled, the pump-cylinder end is likely to wear more rapidly than the steam cylinder. For this reason, pump cylinders are usually provided with replaceable liners.

Cylinder liners are made of almost any kind of material, depending upon the liquid pumped. For example, in the pump for hot oil up to temperatures of 700 F and 500 lb pressure, Fig. 2, nickel steel is used. The pistons, Fig. 1, are made of cast iron, designed for 4 rings of square packing held in place by a follower. For the hot-oil pump, Fig. 2, ordinary packing cannot be used on the piston, so it is provided with hammered-iron self-adjusting packing rings. On this pump, to keep high temperatures away from the packing around the stainless-steel piston rod, a cooling chamber, through which water is circulated, is interposed between the cylinder and stuffing box.

In certain classes of pumps that operate infrequently, as for fire service, the piston or plunger operates as in a sleeve, Fig. 3. In this pump the plunger and sleeve in which it works are made of anti-friction bronze.

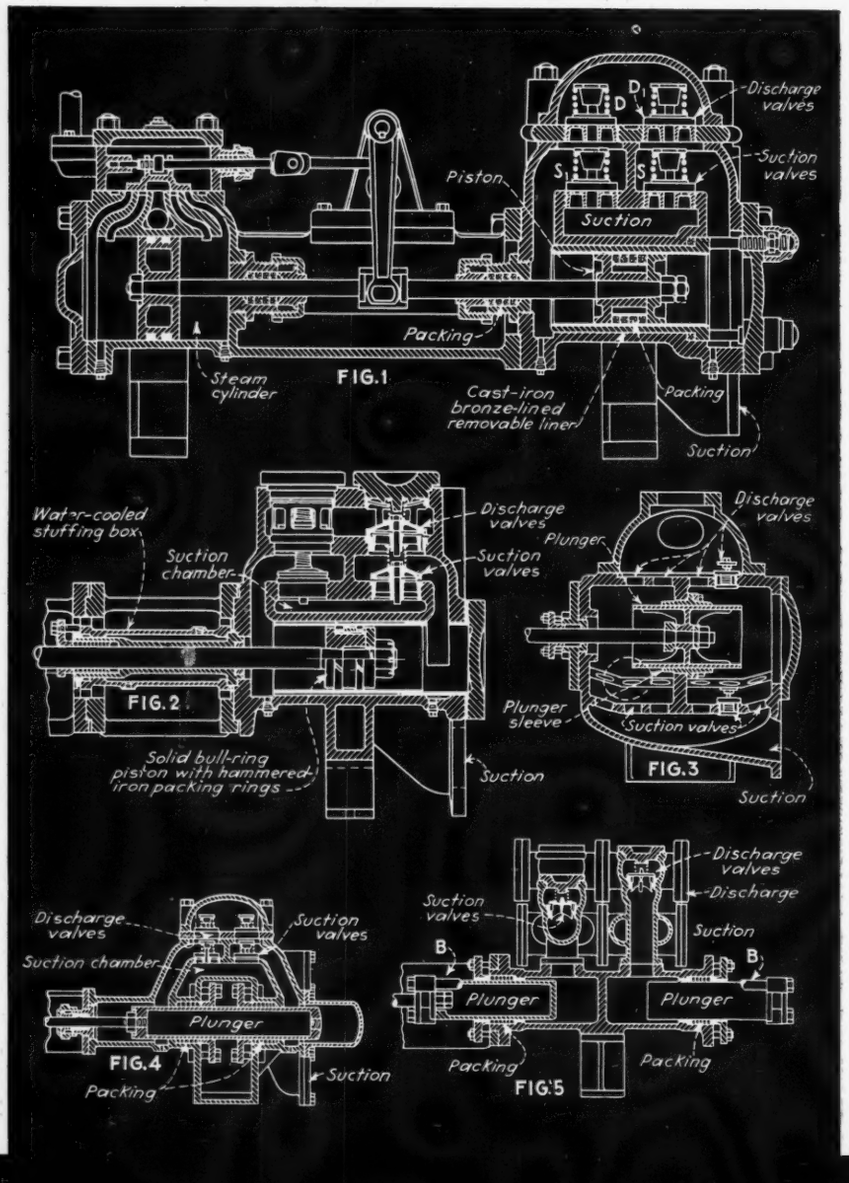
In the many designs of plunger-type pumps, the plunger moves in a stationary packing, Figs. 4 and 5, where in the piston types, Figs. 1 and 2, the packing is carried on the piston. Fig. 3 is strictly a plunger pump because the packing ring in which the piston moves is stationary. Plunger pumps are classified according to their packing location. On the center-packed pump, Fig. 4, the packings are located on the center of the plunger. This design has a single plunger, but requires a packing box on its piston rod. On the outside-packed plunger pump, two opposed plungers are connected by side rods, *B*. The plunger glands are entirely outside the pump where they are readily accessible.

A large number of reciprocating pumps are motor driven, and are generally known as power pumps. These may be of the horizontal type, Fig. 6, or vertical design, Fig. 7. The pistons or plungers in these pumps connect to a crankshaft geared to a countershaft which is connected to the driving motor by a flat belt, gear, vee-belt or chain. Most horizontal power reciprocating pumps are double-acting piston-type, but vertical pumps are usually of the single-acting plunger type, Fig. 7.

Operation

Operation of these pumps is clearly indicated in the figures. For example, in Fig. 1, as the piston moves to the left, fluid flows from the suction into

Fig. 1—Direct-acting steam pump. Fig. 2—High-temperature piston pump. Figs. 3 to 5—Plunger-type pumps



the cylinder through valve S. At the same time, the piston forces liquid out of the left-hand end of the cylinder through discharge valve D. On the reverse stroke, liquid flows into the cylinder through suction valve S_1 and is discharged out valve D_1.

Power-Driven Pumps

Advantages of power-driven reciprocating pumps are: high efficiency, self-priming and ability to deliver constant capacity against widely varying heads. The latter is not true of the centrifugal pump, nor of the direct-acting steam pump, unless it is provided with automatic control. The power pump driven by a constant-speed motor will operate at practically constant capacity up to the pull-out torque of the motor. If discharge is closed, pressure will probably become sufficiently high to wreck the pump before the motor will stall or the motor-protective device opens. For this reason, this pump should be equipped with a pressure-relief valve on the discharge. A direct-acting steam pump will stall as soon as the total pressure acting on the water piston equals that on the steam piston.

Valves

A great many designs of valves and valve arrangements have been developed for the water end of reciprocating pumps. In Figs. 1 and 4, the valves are arranged above the piston in what is called a turret assembly. The discharge-valve seats screw into a plate that can be removed to expose the suction valves. In Fig. 1, the valves are rubber or composition disks on bronze seats, where in Fig. 2, the valve springs and seats are forged heat-treated, stainless steel to operate under high presssures and high temperatures. These valves are in a turret arrangement but have what is known as a pot cover above the valves, which is removed to take out the valves for inspection and repair.

A pot-valve arrangement is shown in Fig. 5. On this pump, each valve is in a pot by itself and can be inspected or renewed by removing the cover from its pot. The valve assembly is made up separate and is bolted to flanges on the pump cylinders. The pumps, Figs. 6 and 7, also have pot-valve construction. In Fig. 6, the valve arrangement is similar to Fig. 2, but the valves are of cast steel faced with hydraulically pressed balata gum and duck composition suited to handling mud or slush. In Fig. 7, two valves are in parallel on the suction and on the discharge side of the pump, each group under a pot cover.

Figs. 8 to 10 show other designs of valves. In Figs. 9 and 10, the suction and discharge valves are on the same guide stem. Fig. 9 uses rubber valve disks for cold fresh water and composition disks on bronze seats for hot water. The bowl valves, Fig. 10, are for heavy viscous fluids and are made without supporting webs in the seat, Fig. 11. A ball-type valve is shown in Fig 8. This type of valve is frequently used where it is desired to provide a free opening for thick liquids. The balls are guided in cages and rest in a free-open circular seat.

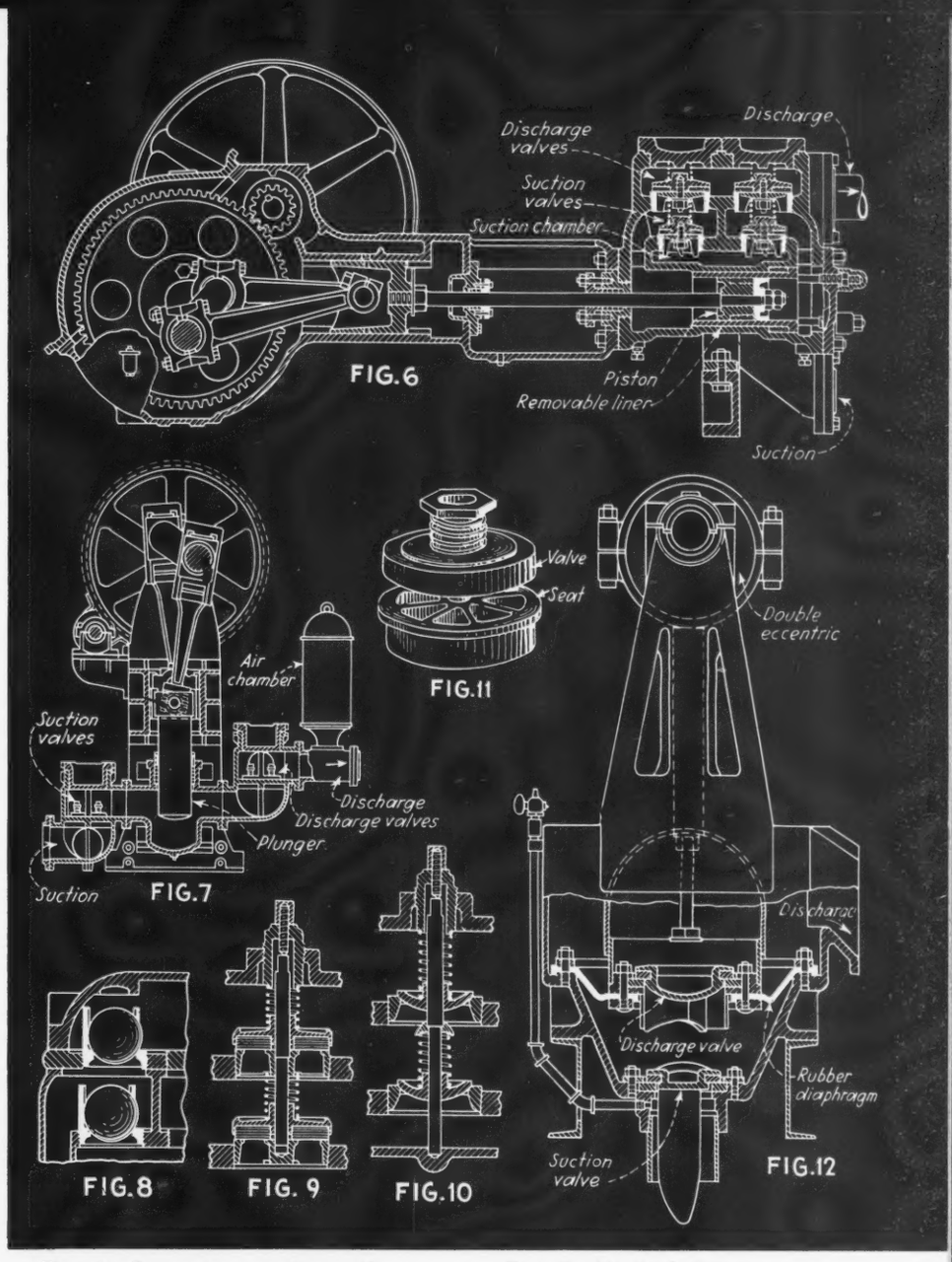


Fig. 6—Power-type reciprocating pump. Fig. 7—Vertical-plunger pump. Fig. 8—Ball valves. Fig. 9—Disk valves. Fig. 10—Bowl valves. Fig. 11—Disk valve and seat. Fig. 12—Diaphragm pump

Diaphragm Pumps

Diaphragm pumps are intended for handling thick pulps, sewage sludge, acids or alkaline solutions, mixtures of water and gritty solids which wear out metal pumps, and for handling liquid solutions where a constant flow volume is required. A cross-section through a pump of this type is shown in Fig. 12. The plunger does not move in a cylinder, but is attached to the center of a circular diaphragm, the outer edge of which bolts to a flange on the pump casing. This diaphragm is made of a special rubber composition to resist corrosion, abrasion, and in special cases, oil and high temperature. On upward movement of the plunger, liquid flows into the pump through the suction valve. Downward movement of the plunger closes the suction valve and the fluid is forced up through the valve in the plunger to discharge.

There are other designs of reciprocating pumps, but the foregoing gives a general idea of the principles involved and types of constructions. They are made for practically every type of service and of a wide variety of materials, including heat-resisting stoneware and hard rubber for handling acid and corrosive solutions.

Deepwell Pumps

WATER, like gold, is where you find it. Frequently, this is deep in the earth, from where water must be brought to the surface by some form of deepwell pump, either plunger, turbine, ejector-centrifugal or air-lift.

Fig. 1 shows the business end of a modern plunger pump. The casing for the check valve and plunger is made of heavy drawn-brass tube of very true bore. The casing is usually placed below water level in the well and extended up to the pump-operating mechanism, at the top of the well, by tubing. Ball, plunger and check valves are used in this pump, but others use disk or other types.

Turbine pumps have come into wide use for both shallow and deep wells. Fig. 2 is a 3-stage pump, each stage having a bowl and runner, made as a standard unit. The number of units in a pump depends upon the head to be pumped against. For high-head pumps, 20 or more stages may be used. The pump column is made of pipe sections 10 ft in length coupled with extra heavy sleeve couplings, or with bolted flanged couplings. Bearing retainers are located in each coupling, and securely anchored between the column-pipe ends, Fig. 2.

Shafts and Bearings

Pump shafts are of stainless steel fitted with non-corrosive metal sleeves at points of bearing contact and run in resilient line-shaft bearings. These bearings are water-lubricated full-flushing. In other designs, stainless-steel sleeves on the shaft run in cutless-rubber bearings. These bearings are particularly suited to applications where amount of sand in the water cannot be kept below a desirable minimum. In other designs of turbine deepwell pumps, the shaft is surrounded by a protecting tube and runs in bronze oil-lubricated bearings, Fig. 3. These bearings are threaded on the outside and form the couplings for the protecting tube.

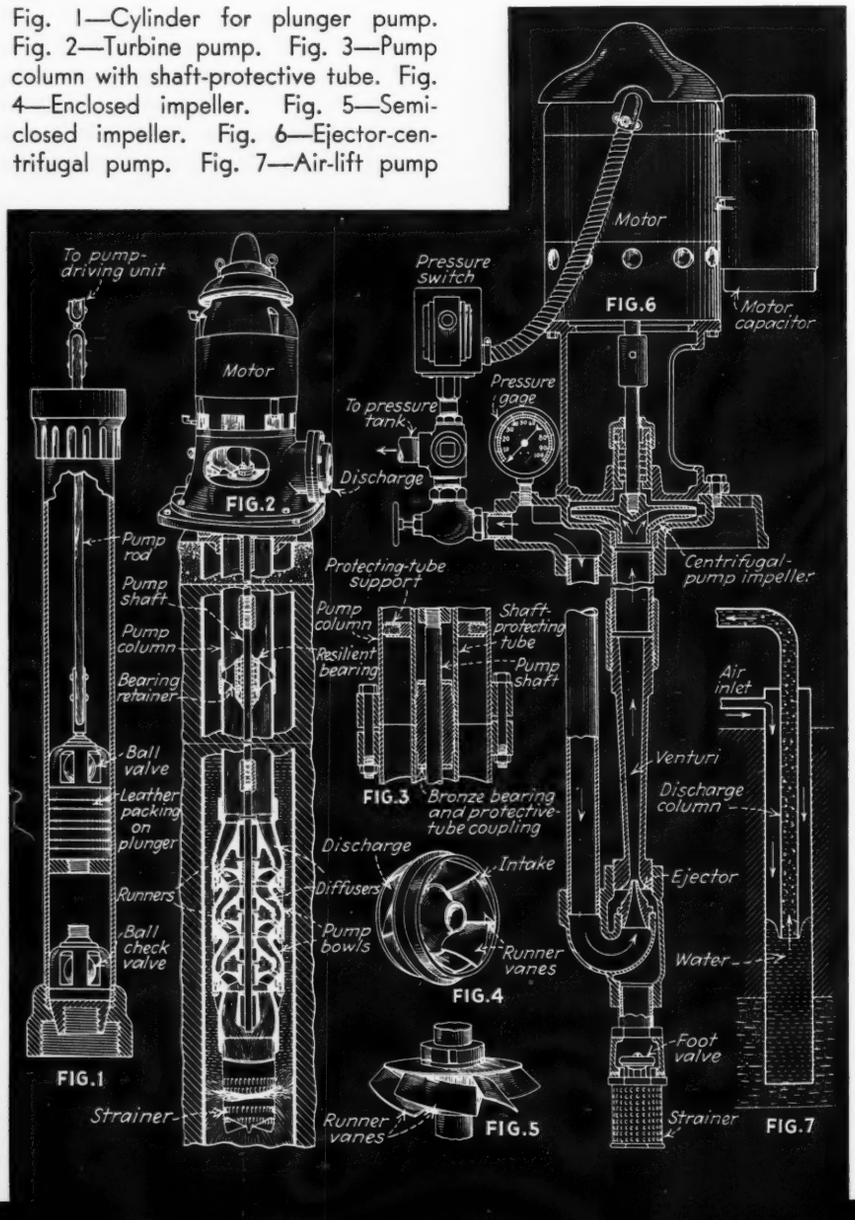
Two types of impellers are used: the semi-open type, Fig. 5, used in the pump, Fig. 2, and the enclosed type, Fig. 4. The latter is very much like a runner for a high-head francis-type water wheel.

Recently, two new designs of submersible deepwell pumps have been announced, described in this number on page 106. In both, the motor is below the pump, and the entire unit is supported in the well from the lower end of the pump casing.

Another form of deepwell pump combines a single-stage centrifugal pump at the top of the well and an ejector located down in the water, Fig. 6. This combination will lift water 200 ft, compared to 15 to 20 ft for a centrifugal pump alone. A predetermined amount of the water pumped flows back through the ejector. This water creates a vacuum above the ejector nozzle, thus allowing additional water from the well to flow into the suction chamber of the ejector. The mixing of the two streams, and the resultant high velocity of the water through the venturi, causes the water to be lifted to within reach of the pump. These units are built for capacities of 6 to 60 gpm and are available with or without automatic control.

A fourth method of pumping wells is by an air lift, Fig. 7, compressed air being admitted to the well to lift water to the surface. Several arrangements of air pipe are in use, but that in the figure shows the general principle. When air is admitted to the well, as in Fig. 7, water recedes from the level of static head to the bottom of the discharge pipe. The displaced column of liquid rises up the discharge pipe and, as the flow of air continues, it enters the pipe, aerating the water and lowering the specific gravity of the mixture. Pressure in the well is momentarily decreased and then increased as the bottom of the discharge pipe is uncovered and covered. The cycle repeats rapidly, producing a nearly constant flow from the top of the discharge pipe.

Fig. 1—Cylinder for plunger pump. Fig. 2—Turbine pump. Fig. 3—Pump column with shaft-protective tube. Fig. 4—Enclosed impeller. Fig. 5—Semi-closed impeller. Fig. 6—Ejector-centrifugal pump. Fig. 7—Air-lift pump



Pump Operation

PUMPS, like people, act differently under different conditions. To intelligently select and operate pumps requires an understanding of what may and may not be expected of them.

For example, capacity and head of a centrifugal pump depend upon speed, impeller diameter and width. At constant speed, capacity decreases as the head increases with a decrease in power input. As head is reduced, capacity and power input increase. Capacity varies as the speed, head varies as speed squared, and power input as the speed cubed. Capacity varies as the impeller diameter, head varies as diameter of impeller squared, and power varies as the impeller diameter cubed.

Performance Curves

Other types of pump may have decidedly different characteristics. On the performance curves for a screw pump, Fig. 1, discharge falls off only about 20% for an increase in pressure from free discharge to 250 lb and brake hp increases almost directly as the pressure. At 100-lb pressure, discharge is 100 gpm and the power input 8 hp. For 200-lb pressure, discharge drops to 87 gpm and brake hp increases to 15.5. For the two conditions, efficiency is 73 and 63% respectively. A screw pump is a positive-discharge rotary type. Some of the other designs, such as gear and vane, may have even a more positive discharge than that shown in Fig. 1.

Fig. 3 shows the characteristic curves for a 300-gpm, 140-ft-head centrifugal pump. Maximum head for this type of pump usually occurs at zero discharge or near that value, and decreases as discharge increases. This pump can be operated against closed discharge without the pressure becoming excessive or overloading the driving unit. The pump represented in Fig. 3 develops, on close discharge, 168-ft head, an increase of only 40% above normal head of 120 ft. Power input drops from 32 hp at 300 gpm to 23 hp at zero discharge.

To reduce the pull-in load on synchronous motors driving centrifugal pumps, they are sometimes started with the discharge valve closed at the pump. It should be mentioned that these pumps cannot be operated continuously on closed discharge or the water in the pump will overheat. With some designs of centrifugal pumps, power input may increase to where the driving unit will overload, because of decreased efficiency.

A comparison between a 42,000-gpm condenser circulating-water centrifugal pump for 17-ft head and a propeller pump of the same rating is made in Fig. 2. At normal rating, these two pumps perform practically alike; head is around 17 ft, efficiency 83% and power input 220 hp. Below 17 ft, head on the propeller type falls off more rapidly than it does on the centrifugal, as does also efficiency. For capacities below normal, obtained by throttling the discharge, head on the propeller pump rises to 54 ft with closed discharge, compared to 27 ft for the centrifugal.

Power input to the centrifugal type drops to 180 hp at zero discharge; that for the propeller type increases to 520 hp, an increase of 136% of rated load, which would seriously overload the driving unit. For this reason, propeller-pump discharge cannot be controlled by throttling. Except at rated capacity, the centrifugal pump has considerably better efficiency and its curve is more flat than that of the propeller pump.

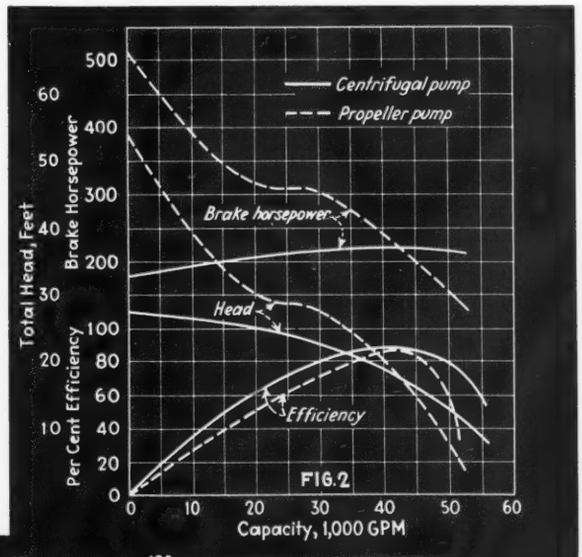
Cutting In or Out

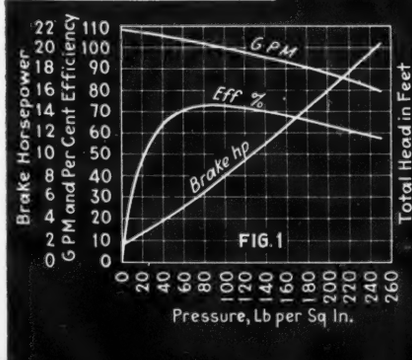
Where two circulating pumps are used in parallel on a condenser, a gate valve is placed in the discharge of each pump so that either or both may be operated. With centrifugal pumps, cutting a pump in or out is a simple matter. If one pump is running and the other is to be put into service, the pump is started and brought up to full speed with the discharge valve closed. Then the valve is opened and the pump goes into service.

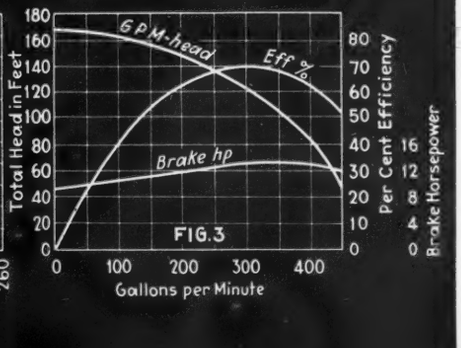
Propeller pumps cannot be operated with the discharge valve closed unless they are provided with oversize motors. Several methods have been used to avoid starting under these conditions. One is to start with the discharge valve partly open, but this requires an automatic non-reversing mechanism to prevent the pump from running backwards, when the valve is opened, until power is applied.

Another method uses a bypass with a check valve around the main valve. This bypass is large enough to keep the power requirements within a safe load on the motor. A full-size check valve with external means for opening may be put in the pump discharge and, after the pump comes up to full speed, the valve is completely opened to reduce head loss. Where speed of the pump can be controlled, it may be partly accelerated with its discharge valve closed, then brought up to speed with the valve open.

Fig. 1—Characteristic curves for a screw-type pump. Fig. 2—Characteristics of propeller and centrifugal pumps. Fig. 3—Head, power and efficiency curves for a centrifugal pump







Boiler-Feed Pumps

BOILER-FEED PUMPS are not a definite type, but rather applications of fairly well established designs, in some cases with modifications. They may be required for pressures of less than 100 lb per sq in. and water temperatures of around 150 F to pressures of about 3000 lb and temperatures exceeding 500 F; capacities may range from about 10 to 2500 gpm. Such a wide range of conditions calls for pumps of substantially different types.

Boiler-feed pumps may be divided into two general classes: reciprocating and centrifugal. As shown in the article on reciprocating pumps, this class is divided into two general types: piston and plunger. These are further subdivided into steam-driven, direct-acting simplex and duplex; and power-driven, horizontal-duplex and -triplex and vertical-duplex and -triplex.

Centrifugal pumps for boiler-feed applications are usually multi-stage and may be either of the volute or turbine design. For low and medium pressures, the volute pump is usually used; either volute or diffuser types are used for high pressures. As a general statement, it may be said that the largest field for reciprocating boiler-feed pumps is in capacities of 400 gpm and less. Large- and medium-size boiler-feed pumps are usually centrifugal. For a more detailed discussion on their selection, see "Boiler-Feed Pumps," pages 62–64, *Power*, Feb. 1937.

Volute Feed Pump

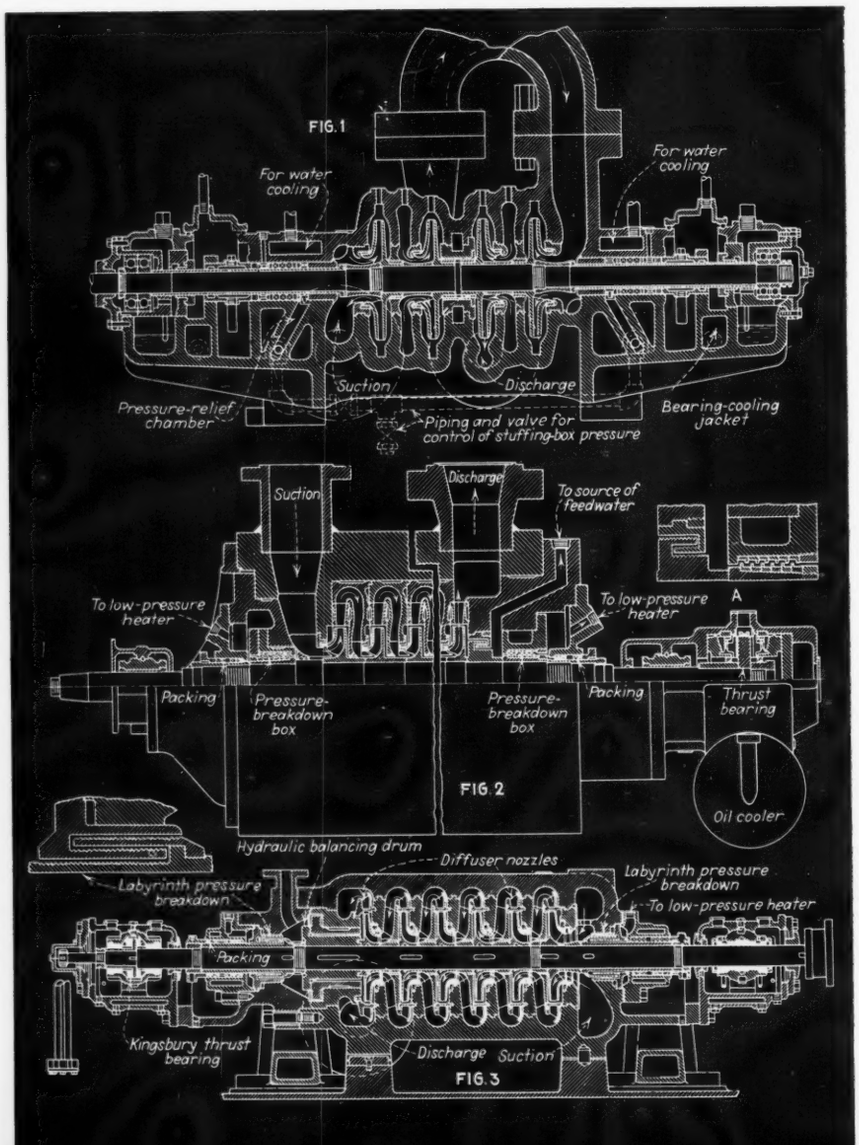
Fig. 1 shows a volute boiler-feed pump with a horizontally split case and impellers arranged to give axial hydraulic balance. Beginning at the suction on the left, water discharged by the first-stage impeller is carried through a volute into the suction of the 2nd stage. Second-stage discharge is led by a long loop around into the suction of the 3rd stage on the right, which discharges through a volute into the 4th stage, the volute of which connects to the pump discharge. Axial thrust produced by the two impellers on the left balances that of the two on the right.

Leakage from the high-pressure 4th stage to the 2nd stage is kept low by a long sleeve and bushing with very small running clearance. Pressure-relief chambers on the stuffing boxes at each end of the pump connect with piping and valves. Leakage from the 1st- and 3rd-stage suctions is throttled through a long sleeve into the relief chambers. Valves in the piping between these two chambers can be set to maintain any desired pressure on the stuffing boxes or relieve it to the lowest pressure in the feedwater system. Ball bearings in the outboard housing are of ample size to take care of end thrust that might occur because of obstructions in an impeller or wear of sealing surfaces.

A cross section of a diffuser-type, high-pressure, high-temperature feed pump with a solid-barrel casing is shown in Fig. 2. The casing barrel is made of forged steel with the suction and discharge nozzles welded in. A forged-steel cover at the discharge end closes the assembly and holds all internal parts in position. The pump, being of the diffuser type, is in radial hydraulic balance, but since impeller suctions all face in the same direction, the rotor develops an axial thrust, taken care of by a Kingsbury thrust bearing.

A small labyrinth balancing drum limits leakage and absorbs some of the load which would otherwise be taken by the main thrust bearing. Be-

Fig. 1—4-stage pump with opposed impellers to give axial hydraulic balance. Fig. 2—Diffuser-type high-pressure pump with forged-steel casing. Fig. 3—6-stage high-pressure diffuser-type pump with horizontally split casing



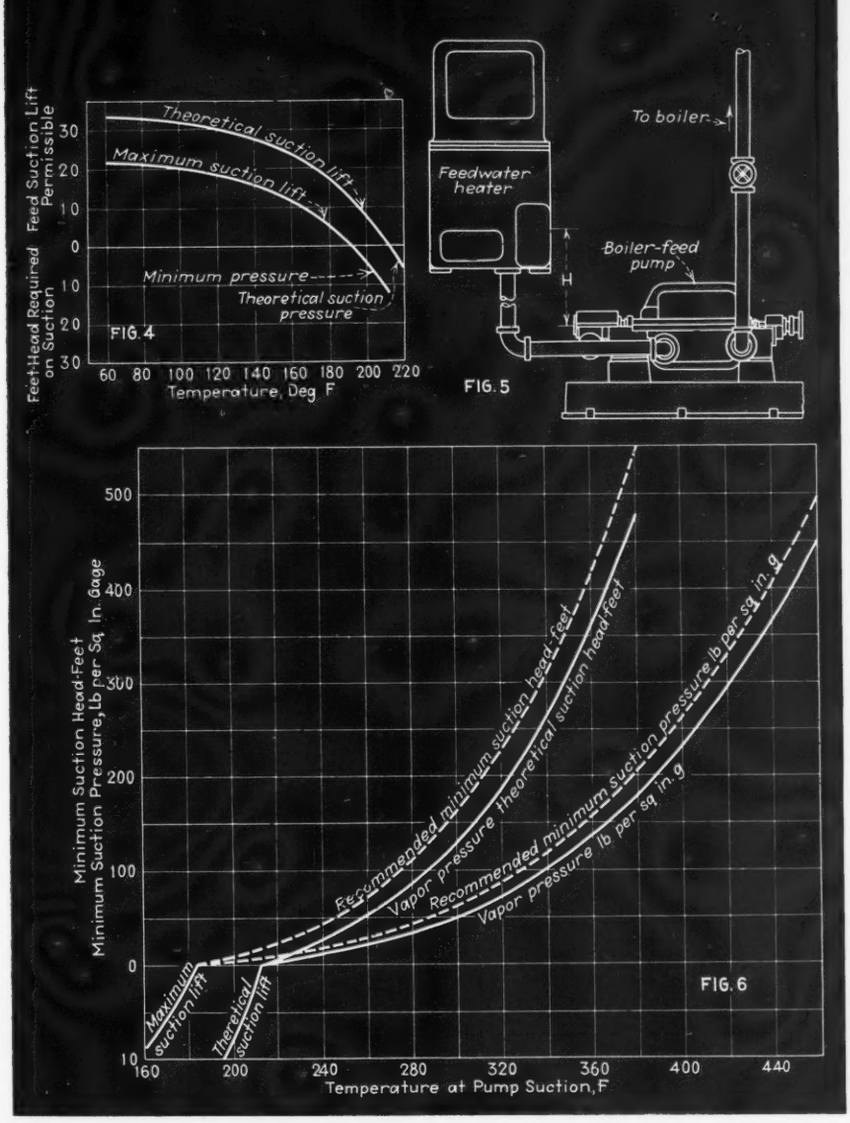


Fig. 4—Theoretical and practical suction lifts for water at various temperatures. Fig. 5—Height of feedwater heater above pump suction depends upon water temperature. Fig. 6—Minimum suction head at eye of boiler-feed pumps as recommended by Hydraulic Institute standards

tween the balancing chamber and the stuffing box is a breakdown labyrinth system, shown enlarged at *A*, which further reduces the leakage and protects the stuffing box from high pressure and temperature. A similar breakdown labyrinth system protects the stuffing box on the suction end.

The rotor runs in sleeve bearings, oil for which (and also for the thrust bearing) is provided by a viscosity pump, mounted on the thrust bearing. The oil is cooled by a separate oil cooler through water circulation.

The high-pressure, high-temperature boiler-feed pump, Fig. 3, has a horizontally split case. All impellers are single suction, face in the same direction and are surrounded by rings of diffuser nozzles. The suction is on the right and flow through the pump can be easily followed by the arrows.

Being a diffuser pump, it is in radial hydraulic balance. Axial hydraulic thrust is taken by a balancing drum which rotates within a stationary sleeve beyond the last stage. Total thrust due to unbalanced area of all the impellers is neutralized by water under discharge pressure operating against the inside face of the drum flange. Leakage through the balancing drum is piped back into the pump's suction. A Kingsbury thrust bearing supplements the hydraulic balancing device, to maintain the rotor in longitudinal alignment and take care of thrust caused by wear and abnormal operating conditions.

Labyrinth Seal

A triple-labyrinth seal, interposed between the balancing-drum discharge chamber and the stuffing on the discharge end and between the suction chamber and stuffing box on the low-pressure end, keeps pressure on the packing at low value. An enlarged section of this labyrinth is shown at the left. Leakage through the labyrinth is piped to the lowest pressure point in the feedwater system. The stuffing boxes also provide for water cooling if conditions require this.

Many of the troubles experienced with boiler-feed-pump operation are chargeable to insufficient head on the suction and other unfavorable conditions at the suction. Minimum suction head varies with water temperature. As shown in Fig. 4, a centrifugal pump may be expected, when handling 60-F water, to operate satisfactorily against a suction lift of 21 ft. If water temperature is 212 F, then a static head of about 17 ft should be maintained on the pump suction. These are the conditions that must exist at the eye of the pump runner when all losses in the suction pipe are taken into account.

If there is 5-ft head loss in the suction pipe and fittings, then the center line of the pump handling 60-F water can be only $21 - 5 = 16$ ft above minimum suction well level. With 212-F water, the heater should be located so that its minimum water level will never be less than $17 + 5 = 22$ ft above the center line of the pump. This height is indicated by *H*, Fig. 5, with atmos. pressure in the heater.

Effective Heads

Fig. 6 gives curves of theoretical and recommended effective heads in feet and pressures in lb per sq in., recommended by the Hydraulic Institute standards. Suction heads are based on a suction head of 14 ft in excess of the liquid-vapor pressure, plus a safety factor for a sudden change in temperature in the feedwater. The safety factor is calculated on a basis of 2% change in feedwater temperature. For 212-F water, this gives a total recommended suction head of 15 ft and for 360-F water, 430 ft. Of course, in the latter case, a large part of this head will be pressure in the heater.

For example, at 360 F, recommended suction pressure at the pump is 155 lb g. Vapor pressure corresponding to the water temperature is 140 lb g. Allowing a differential of 5 lb, the result is a total pressure in the heater of 145 lb, leaving $155 - 145 = 10$-lb suction pressure to be obtained by elevating the heater above the pump. For 360-F water, this would amount to about 26 ft.

When conditions make it necessary to operate at lower suction heads than the recommended values given by the curves, special care must be taken in selecting the pump. The necessity of using suction piping of ample size and running it as direct as possible, to keep the friction losses at a minimum, cannot be over-emphasized. If suction-pipe friction losses are high, a sudden demand for water from the heater may cause the suction head to drop to where the water will flash, causing the pump to fail at a time when steam demand from the boiler is greatest.

Pump Priming

POSITIVE-DISPLACEMENT pumps, such as reciprocating and rotary, if in good condition, are self-priming, if in good suction lifts up to about 25 ft. Centrifugal pumps are not self-priming and, when operated on a suction lift, means must be provided to prime them, as for example, from a connection to the city supply. When a pump is to be primed, water is allowed to run into the suction pipe until it begins to flow from the cock on top of the pump casing. If the foot valve is tight, once the pump is primed, it should always remain so. If the discharge pipe remains full of water, the pump can be primed by a bypass around the check valve in the discharge line. This method also requires a foot valve.

On small pumps with short suction lines, requiring infrequent priming, a hand-operated vacuum pump may be connected into the top of the pump casing to exhaust the air.

Ejectors

Ejectors operated by steam, compressed air or water under pressure may be used for priming. Fig. 1 shows a cross section of such an ejector. The ejecting medium is admitted at *E*, and passes through *D* and draws air in at *S*, which is connected to the pump casing as in Fig. 2. To prime the pump, open valve *V* in the steam or air line, then open valve *V*, in the suction of the ejector. When water starts to flow from the discharge pipe of the exhauster, the pump is primed and the valves may be closed. If the suction line is long, a foot valve should be used.

Where a source of vacuum, such as a condenser in a power station, is available, it may be connected to the top of the pump casing and controlled by a valve for priming.

Vacuum pumps are used extensively to prime centrifugal pumps, either by manual or automatic control. Fig. 3 shows an arrangement for priming with a rotary vacuum pump. When the centrifugal pump is to be primed, the vacuum priming pump is started. After priming, the vacuum pump is shut down and the valves closed in the air and water lines. A relief valve is provided to open at a vacuum slightly higher than that actually required to flood the centrifugal pump casing. This prevents water from coming over into the vacuum pump. Opening of the relief valve is an indication that the centrifugal pump is primed. For conditions requiring continuous operation of the vacuum pump, the arrangement shown in full line in Fig. 3 may be used, except that valve *V* may be omitted. For automatic operation of the primer, a pressure regulator may be connected into the discharge, as indicated by the dotted line. This regulator starts the vacuum pump automatically if the main pump loses its prime and stops the priming pump when priming is complete.

Automatic System

An automatic priming system for centrifugal pumps is shown in Fig. 4. A priming valve is connected between the top of the pump casing and a float-controlled air valve. The air valve connects to a timing switch, the contacts of which are in series with the control circuit of the main motor starter. A check valve in the discharge line operates a switch that shunts the priming switch. As long as the pump is not primed the priming valve and air valve are in the position indicated. When the float switch closes, it starts the priming pump, which continues to operate until the main pump is primed and water has come up high enough in the float chamber to close the priming switch.

Closing the priming switch starts the main pump and the priming pump is stopped by a contact that opens when the pump-motor-control circuit is energized. When the main pump is running, the discharge check valve is held open and the contacts on its switch are closed to complete a holding circuit for the pump-motor contractor, around the priming switch. This, of course, allows the priming switch to open without shutting down the pump.

A centrifugal pump may be made self-priming by connecting a comparatively large chamber to the suction, as in Fig. 5. The priming tank is divided by a horizontal partition; the pump suction connects to the bottom of the lower half and the discharge to the bottom of the top half. When the pump starts, it transfers water from the bottom half to the top of the tank. As water lowers in the bottom half, it reduces air pressure in the suction line until water begins to flow into the tank and the pump goes into regular operation.

When the pump stops, water flows by gravity into the pump and the lower half of the tank, air entering through the valve at the top of the tank. This backflow of water forces air out of the lower half of the tank and leaves it and the pump casing full of water ready for the next operation. A small pipe connection between the discharge pipe and priming tank acts as a vacuum breaker and insures that the priming tank and pump remains full of water. The air valve at the top of the tank will pass air in or out of the tank but will not allow water to flow. The latter operation is taken care of by a float-operated valve. Suction lift for which this system can be used depends upon length and size of suction pipe and size of priming tank.

For Any Pump

Fig. 6 is an arrangement for automatically priming a pump and keeping it primed. This equipment can be attached to any pump. The float chamber *C* is attached to the suction of the pump. A float-operated switch *S*, in the top of the float chamber, starts and stops the separately driven vacuum pump for priming the centrifugal pump. The float also controls the vacuum check valve *V*.

When the pump is not primed, the float is at the bottom of the chamber and the switch *S* is closed to start the vacuum pump, valve *V* being open to connect the float chamber to the vacuum producer. As the vacuum pump exhausts air from the float chamber, water rises into it and the intake of the pump. When the float has been raised to the position in the figure, the switch is tilted to stop the vacuum pump and valve *V* is closed to seal chamber *C* from the vacuum device.

As long as vacuum is maintained in the float chamber, the float will remain in a position to hold switch *S* open. If vacuum fails, liquid level will fall in the float chamber until the float starts the vacuum producer to restore water level. This keeps the pump primed at all times. An equalizing pipe, connecting the top of the float chamber to the centrifugal-pump casing surrounding the eye of the impeller, permits water to rise in the casing, thus priming the pump.

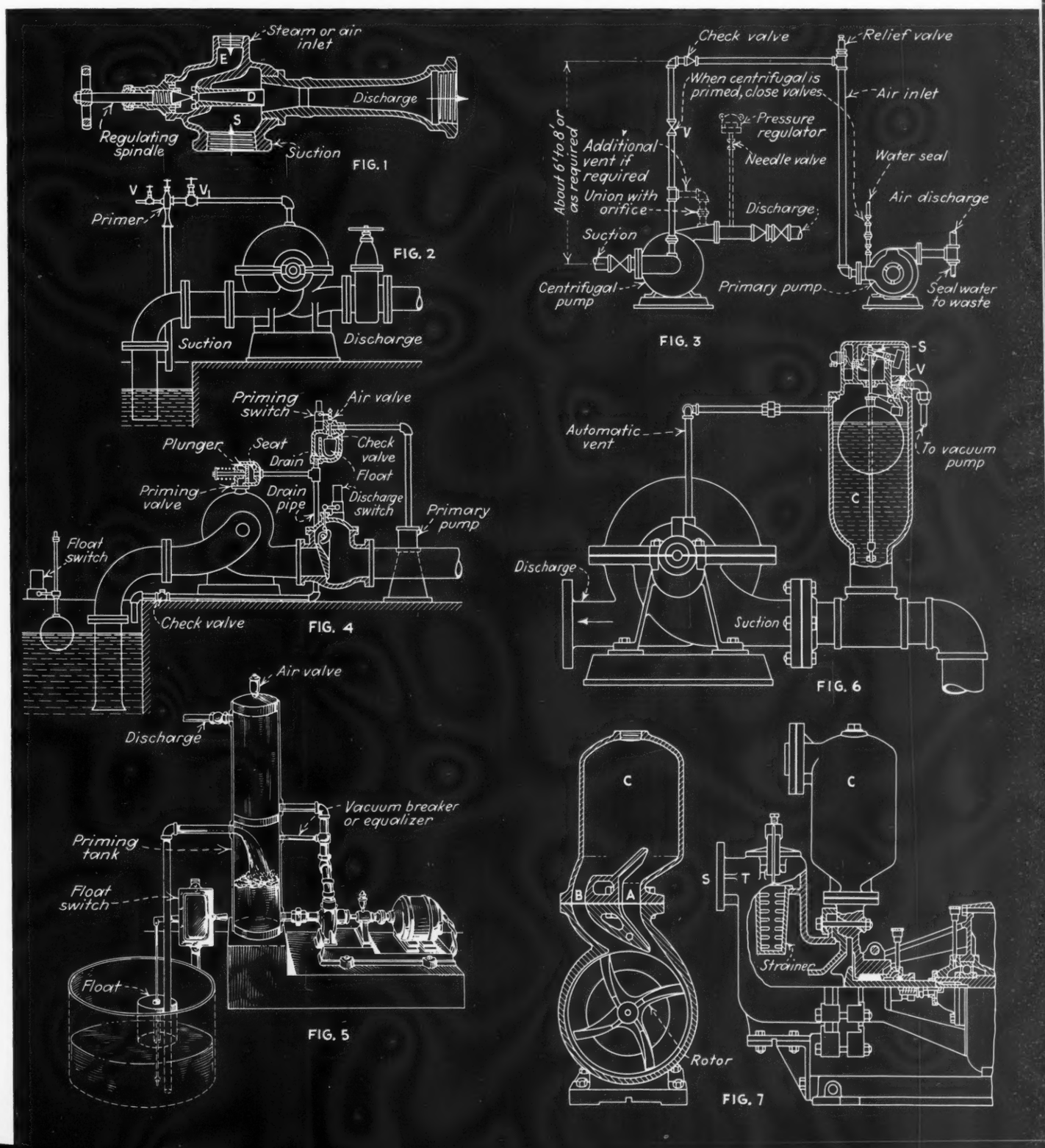
The vacuum producer may be con-

nected to a battery of pumps to keep them primed. In that case, all float-chamber switches are connected in parallel and vacuum-sealing-valve connections are also connected together to the vacuum pump. When all the pumps are primed, the vacuum producer is shut down. Should the vacuum in any float chamber decrease until a float closes its switch, the vacuum pump will be started and water level restored in the float chamber. This system may also be applied to a steam, air or water-operated ejector for priming pumps and keeping them primed.

Several designs of self-priming pumps are available. In the one, Fig. 7, the suction pipe connects at *S* to trap *T*. After the pump has been once primed, the trap retains a supply of water at the suction to insure that it will be self-priming. On top of the pump casing is an air chamber *C*, in which air separates from the water when the pump is being primed. The discharge pipe connects to the top of this chamber.

When the pump is started, water trapped in the casing is discharged up through passage *A* into the air separator where it is freed of air and flows back through passage *B* into the pump. This process continues until the pump is primed. When prime has been established, there is too much water to pass out of opening *A*; consequently, the surplus goes out through *B*. This feature prevents recirculation of water in the pump after it has been primed and it operates as a normal centrifugal pump.

Fig. 1—Section through ejector-type pump primer. Fig. 2—Ejector connected to prime a centrifugal pump. Fig. 3—Vacuum pump connected for priming. Fig. 4—Float-controlled automatic priming system. Fig. 5—Automatic system uses a divided tank for priming. Fig. 6—Automatic primer using a separate vacuum producer. Fig. 7—Sections through a self-priming pump



Pump Drives

MODERN PUMPS are usually driven by steam turbines, internal-combustion engines or electric motors. Type of drive selected will depend upon kind of power available (size of pumping unit, type of pump, speed control required and other conditions.

Where steam is available, and all exhaust steam can be used for heating, centrifugal pumps are frequently driven by steam turbines. In waterworks, condensing turbines may be used. Turbines may be either direct connected or geared to the pumps, depending on the type of turbine and head under which the pump operates. High-head pumps, such as boiler feed, are usually direct connected, whereas low- and medium-head pumps are frequently gear driven. With turbine drive, control of pump output is readily and efficiently obtained by speed adjustment (throttling the turbine).

For high reliability of operation, a dual drive (turbine and motor) is sometimes used. Normally, the motor does the driving and the turbine governor is so set that the turbine takes just sufficient steam to keep it from overheating. If power to the motor fails, speed drops slightly and the governor causes the turbine to pick up load.

In water works and on oil pipelines diesels frequently drive pumps. Centrifugal pumps usually operate at higher speeds than diesel engines and a speed-increasing gear unit connects engine and pump. For emergency pumping units, such as fire pumps, gasoline- or gas-engine-driven pumps are used quite extensively.

Motor Drives

Motor drives are most widely used. These may be divided into two groups: constant discharge and variable discharge. For small pumps, operating on constant discharge, either single-phase or polyphase squirrel-cage motors may be applied, started and stopped by a simple float or pressure switch and magnetic contactor. These motors are of a size that permits starting by connecting them across the line under all conditions.

For medium and large capacity pumps, polyphase squirrel-cage and synchronous motors are used for constant-speed and -discharge conditions. Sometimes, for constant-speed applications, wound-rotor induction motors meet low-starting-current requirements. When power factor is an element, synchronous motors are used frequently, particularly for capacities of 50 hp and above. These motors are of two general types: those designed to operate at unity power factor, and at 80% power factor at full load. The unity-power-factor motor is used where normal power-factor connection is needed and the 80% power-factor motor is selected for conditions requiring maximum correction. The 80% power-factor motor is in fact oversize and is sometimes selected to meet starting and pull-in torque requirements.

Below 50 hp, squirrel-cage induction motors are generally used for constant-speed drives where ac power is available. This motor is manufactured in a number of types with starting torques to suit various starting conditions and current-peak requirements.

Centrifugal pumps started unloaded require a starting torque of 15 to 20% of full-load value. When started loaded, starting torque is around 20 to 30%. Pull-in torque unloaded is 40 to 60% and loaded 100 to 110%. Reciprocating pumps, when started unloaded, require a starting torque of 50 to 75% of full-load value and when started loaded, starting torque may be 125 to 200% full-load value. Pull-in torque unloaded is 25 to 50% and loaded 110 to 115%. Centrifugal pumps can be unloaded by closing the discharge valve during starting and reciprocating pumps are unloaded by bypassing the pump or by holding the suction valves open.

Adjustable Discharge

Where adjustable discharge is required with motor-driven reciprocating pumps, some type of adjustable-speed motor or a constant speed motor with variable-speed transmission must be used. On ac-power lines, either wound-rotor or commutator-type polyphase motors will provide necessary speed adjustment. Where dc power is available, use shunt-type motors. The same recommendations apply to centrifugal pumps where it is desirable to vary pump discharge by speed control. However, it is frequently more economical to drive the pump at constant speed and adjust discharge by throttling. The table, based on information supplied by A M Jones of Westinghouse Elec & Mfg Co, will serve as a guide in selecting motors for pump drives.

MOTOR APPLICATIONS FOR PUMPS

Pump Type	*Pump Size*	*Power Circuit*	*Motor Type*	*Drive Type*	*Capacity Control*
Constant-speed centrifugal	Small	Single-phase	Single-phase, repulsion-ind. or capacitor type	Direct, belt, chain or gear	Throttling discharge
Constant-speed centrifugal	Small and medium	2 or 3 phase	Squirrel-cage	Direct, belt, chain or gear	Throttling discharge
Constant-speed centrifugal	Medium and large	2 or 3 phase	Induction and synchronous	Direct, belt, chain or gear	Throttling discharge
	For dc, use shunt-wound motors on all except small units, where compound-wound motors are recommended.				
Adjustable-speed centrifugal	Medium	2 or 3 phase	Slip-ring or commutator	Direct, belt, chain or gear	Adjusting speed
Adjustable-speed centrifugal	Medium	dc	Shunt-wound	Direct, belt, chain or gear	Adjusting speed
Constant-speed reciprocating	Small	Single phase	Single-phase, repulsion-ind. or capacitor	Belt, chain or gear	Bypass
Constant-speed reciprocating	Small and medium	2 or 3 phase	High-torque squirrel-cage or slip-ring	Belt, chain or gear	Bypass
Constant-speed reciprocating	Medium and large	2 or 3 phase	High-torque induction and synchronous	Direct, belt, chain or gear	Bypass
	For dc power, use compound motors				
Adjustable-speed reciprocating	Medium and large	2 or 3 phase	Slip-ring or commutator	Belt, chain or gear	Adjust speed
Adjustable-speed reciprocating	Medium and large	dc	Shunt-wound	Direct, belt, chain or gear	Adjust speed

Oil & Gas Power

Hitting Its Stride

COMPARED with water power and steam, oil and gas power is as new as this morning's newspaper. Water-power beginnings are lost in the mists of time, and men were toying with steam before people got the habit of recording history. First suggestion of the internal-combustion idea didn't come until 1680 when Huyghens, Dutch physicist, talked of making gunpowder do useful work by exploding it in a closed vessel with a movable top. It is a far cry from this random thought to modern oil and gas engines, but since Lenoir, Beau de Rochas, Otto, Diesel and Ackroyd-Stuart made their vital contributions, oil and gas power has made great strides. Still overshadowed by steam and hydro when total stationary output is considered, internal combustion reigns supreme in the mobile field, and is setting new standards of performance in those sections of the stationary field where it works to best advantage.

Outstanding recent trend is the more intelligent use of oil and gas power based on clearer understanding of its characteristics. Steam engineers no longer regard the unfamiliar internal-combustion engine with mistrust. More and more they see oil and gas power as another tool in the Btu-chasing kit, to be used wherever circumstances dictate. Conversely, oil and gas power enthusiasts now realize the broader possibilities of these prime movers when linked with steam and hydro to cut total power and heat costs. Everything points to a continued integration of the power-engineering art, with oil and gas power an essential element rather than an entirely separate field.

Power engineers, thinking in this modern way, find constantly improved internal-combustion engines and accessory equipment available for the job. The engineering data on more than 550 recently installed oil- and gas-engine plants, listed on the following pages, tell the story of this steady progress. Highlights include cooling of jacket water with evaporative condensers, borrowed from air conditioning practice; continued success of the gas-burning diesel and increased use of convertible gas-oil units; advances in making cheap power from sewage-sludge gas; and improvements in engine manufacture promising even better engines at lower cost.

This year's oil engine follows the trends of recent years, and is a multiple-cylinder unit of small bore and stroke, running at higher speeds to reduce weight and cost. Four-cycle engines are in the majority below 1000 hp; above this size the 2-cycle dominates. Indications are that 2-cycle engines will be more widely used in all sizes as design improvements make it possible to get the advantages of simplicity and cheapness without the usual disadvantages. The 7000-hp units for the Salt River Valley Water Users' Association equal the size record for the United States and are the first double-acting engines to be built in this country for several years.

What might be termed the "renaissance of the gas engine" is taking place as this long-used prime mover learns new ways to make the most of pipeline extensions bringing gas fuel to many parts of the country. Once principally used in steel mills, gas plants, and oil fields, gas-powered units now find acceptance in the general power field. The modern gas engine, like its oil-engine counterpart, is likely to be a vertical multi-cylinder unit, running at higher speeds. It is versatile, burning many gases, chief newcomers being sewage-sludge gas and butane. Largest vertical gas engine yet built is the 2200-hp unit for Southwestern Public Service Co.

So much for design trends. What do they mean to the power engineer? Simply that oil and gas power is taking its rightful place in the power picture and should have a corner in every power man's thinking. To aid this thinking, *Power's* Oil and Gas Power Section includes two pages of handy facts, highlight data on internal combustion. For fundamental ideas and detailed information, refer to previous special sections, June, 1936, and June, 1935.

Oil & Gas Power

Diesel Installations

406 Plants, 557 Engines

Installed Since January 1, 1937

Service	Equip. Driven	Engine Builder	No. Units	Hp Each	Rpm	No. Cyl	Cyl Bore	Cyl Stroke	Cycle	Starting Method	Fuel Injection	Fuel, lb per hp hr
Salt Riv. Valley Water Assn.	Phoenix, Ariz	Lt. & Pwr.	Gen.	HOR	2	7000	167	8	24	36	2*	A	S	0.39
Rockville Center	Long Island, N. Y.	Mun. Add.	Gen.	ALC	1	2865	120	8	29	48	4	A	S	....
Lubbock	Texas	Mun. Add.	Gen.	Nor	1	2250	225	6	21	29	2	A	A	....
Carthage	Missouri	Mun. Pwr.	Gen.	Nor	1	2250	225	6	21	29	2	A	S	....
Imperial Valley Irrig. Dist.	Brawley, Calif.	Lt. & Pwr.	Gen.	HOR	3	2200	240	6	21½	27½	2	A	S	0.39
Greenville	Texas	Mun. Pwr.	Gen.	Nor	1	2000	257	8	17	25	2	A	S	....
McMinnville	Oregon	Mun. Add.	Gen.	BuS	1	1800	240	6	19½	27	2	A	S	0.40
Miami	Oklahoma	Mun. Pwr.	Gen.	Nor	1	1500	257	6	17	25	2	A	A	....
Island Gas & Elec. Co.	Haiti	C.S. Pwr.	Gen.	Nor	1	1500	257	6	17	25	2	A	S	....
Goshen	Indiana	Mun. Add.	Gen.	F-M	1	1400	300	8	16	20	2	A	S	0.39
Sikeston	Missouri	Mun. Add.	Gen.	F-M	1	1400	300	8	16	20	2	A	S	0.39
Marshall	Minnesota	Mun. Add.	Gen.	F-M	1	1400	300	8	16	20	2	A	S	0.39
Estherville	Iowa	Mun. Add.	Gen.	BuS	1	1285	257	4	19½	27	2	A	S	0.39
Belton Lt. & Pwr. Co.	Belton, S. C.	C.S. Pwr.	Gen.	Nor	1	1250	257	5	17	25	2	A	A	....
Georgetown	S. Carolina	Mun. Add.	Gen.	F-M	1	1050	300	6	16	20	2	A	S	0.39
Butler	Missouri	Mun. Add.	Gen.	F-M	1	1050	300	6	16	20	2	A	S	0.39
Rural Elec. Administration	Pocahontas, Iowa	Lt. & Pwr.	Gen.	FIW	2	1000	225	8	17½	24½	4	A	S	0.39
					1	750	225	6	17½	24½	4	A	S	0.39
Jackson	Missouri	Mun. Pwr.	Gen.,	ALC	1	1000	225	8	17½	25	4	A	S	....
Osceola	Arkansas	Power	Gen.	Wor	1	1000	225	8	17	25	4	A	S	....
Wisconsin Power Coop'tive	Chippewa Falls, Wis.	Power	Gen.	BuS	3	1000	257	8	16¼	24½	4	A	S	0.39
Fed. Coop. Power Co.	Hampton, Iowa	C.S. Pwr.	Gen.	Nor	1	1000	257	4	17	25	2	A	S	....
					1	750	257	3	17	25	2	A	S	....
875–415 hp per Engine														
Sabetha	Kansas	Mun. Add.	Gen.	F-M	1	875	300	5	16	20	2	A	S	0.39
Ipswich Water & Lt. Co.	Ipswich, Mass.	Mun. Add.	Gen.	F-M	1	875	300	5	16	20	2	A	S	0.39
B. Altman & Co.	New York, N. Y.	Pwr.	Gen.	ALC	2	860	257	6	17½	25	4	A	S	....
Packard Dredging Co.	Boston, Mass.	Dredge	Pump	Sup	1	810	360	8	14½	18	4	A	S	....
Elko Lamoille Power Co.	Elko, Nev.	C.S. Pwr.	Gen.	BuS	1	750	257	6	16¼	24½	4	A	S	0.39
Oxford	Mississippi	Mun. Pwr.	Gen.	ALC	1	750	225	6	17½	25	4	A	S	....
Holdredge	Nebraska	Mun. Pwr.	Gen.	F-M	1	750	257	5	16	20	2	A	S	....
Vermillion	S. Dakota	Power	Gen.	Wor	1	750	327	6	16	20	4	A	S	....
Minden	Nebraska	Power	Gen.	Wor	1	750	225	6	17	25	4	A	S	....
Utilities Purchase & Supply Co.	.....	Power	Gen.	ALC	1	715	257	5	17½	25	4	A	S	....
U. S. Gypsum Co.	Midland, Cal.	Power	Gen.	F-M	1	700	300	4	16	20	2	A	S	0.39
Goodland	Kansas	Mun. Pwr.	Gen.	F-M	1	700	300	4	16	20	2	A	S	0.39
					1	500	400	5	12	15	2	A	S	0.40
Corning	Iowa	Mun. Add.	Gen.	F-M	1	700	300	4	16	20	2	A	S	0.39
Delta	Colorado	Mun. Add.	Gen.	F-M	1	700	300	4	16	20	2	A	S	0.39
Huntsville Prison	Huntsville, Tex.	Power	Gen.	Sup	1	685	327	8	14½	18	4	A	C	....
					1	520	400	8	12½	15	4	A	C	....
					1	325	400	5	12½	15	4	A	C	....
Trenton	Missouri	Mun. Pwr.	Gen.	F-M	3	650	..	..	..	..	2	A	S	....
Fayette	Missouri	Mun. Pwr.	Gen.	F-M	1	630	..	..	..	..	2	A	S	....
Ill. Rural Elect. Co.	Alsey, Ill.	Power	Gen.	BuS	3	625	257	5	16¼	24½	4	A	S	0.39
Texas Company	.....	Oil	Pump	ALC	1	625	227	5	17½	25	4	A	S	....
Waverly	Iowa	Power	Gen.	Wor	2	625	327	5	16	20	4	A	S	....
S. Antonio Portland Cement Co.	Cementville, Tex.	Power	Gen.	BuS	1	625	257	5	16¼	24½	4	A	S	0.39
Carter Mills No. 1	Lincolnton, N. C.	Cotton	Gin	Buc	1	600	360	8	13½	15½	4	A	S	0.40
Hawaiian Pineapple Co.	Honolulu, T. H.	Power	Gen.	BuS	1	600	360	8	13	17	4	A	S	0.40
Fla. Pub. Utilities Co.	Fernandina, Fla.	C.S. Pwr.	Gen.	BuS	1	600	225	6	16¼	21	4	A	A	0.43
The Blanton Co.	Helena, Ark.	Power	Shaft	BuS	1	600	360	8	13	17	4	A	S	0.40
Tex.-N. Mex. Pipe Line Co.	New Ulm, Katy, Tex.	Oil	Pump	BuS	4	600	360	8	13	17	4	A	A	0.43
Texas State Farm	Sugarland, Tex.	Power	Gen.	C-B	1	600	277	..	15½	22	4	A	S	....
Dowagiac	Michigan	Mun. Pwr.	Gen.	F-M	1	575	300	5	14	17	2	A	S	....
					1	225	....	..	..	..	2	A	S	....
U. S. Smelt. & Ref. Co.	Salt Lake City, Utah	Power	Gen.	F-M	1	575	300	5	14	17	2	A	S	0.40
Malden	Missouri	Mun. Add.	Gen.	F-M	1	575	300	5	14	17	2	A	S	0.40
Nickey Bros. Co.	Memphis, Tenn.	Power	Gen.	Sup	1	560	400	8	12½	15	4	A	S	....
Shenandoah Valley Elec.	Dayton, Va.	Power	Gen.	Wor	1	500	360	6	13¼	17½	4	A	S	....
					1	415	360	5	13¼	17½	4	A	S	....
					1	250	360	3	13¼	17½	4	A	S	....
Palmyra	Missouri	Mun. Pwr.	Gen.	FIW	1	500	225	4	17½	24½	4	A	S	0.39
Terrell	Texas	Mun. Pwr.	Gen.	F-M	1	450	300	6	14	17	2	A	S	....
Holyoke	Colorado	Mun. Pwr.	Gen.	F-M	1	450	300	6	14	17	2	A	S	....
U. S. Engineers	Fort Peck, Mont.	Dam Gates	Gen.	Ent	1	450	360	8	12	15	4	A	S	0.39
Glencoe	Minnesota	Mun. Pwr.	Gen.	F-M	1	450	300	6	14	17	2	A	S	....
					1	300	360	6	10½	12½	2	A	S	....
Hudson Cotton Mfg. Co.	Hudson, N. C.	Power	Alt.	Buc	1	450	360	6	13½	15½	4	A	S	0.40
West Liberty	Iowa	Power	Alt.	Buc	1	450	360	6	13½	15½	4	A	S	0.40
Beresford	South Dakota	Mun. Pwr.	Gen.	FIW	1	450	300	6	13¾	18	4	A	S	0.39
Korn Leather Co.	Peabody, Mass.	Pwr.	Gen.	Wor	1	450	327	6	13¼	17½	4	A	S	....
Bellevue	Iowa	Power	Gen.	Wor	1	450	327	6	13¼	17½	4	A	S	....
Delaware Dredging Co.	Wilmington, Del.	Power	Gen.	Sup	1	420	400	6	12½	15	4	A	S	....
S. B. Brooks Co.	Sea Bright, N. J.	Power	Gen.	Sup	1	420	400	6	12½	15	4	A	S	....
N. Y. Telephone Co.	New York, N. Y.	Standby	Gen.	ALC	1	415	720	8	9½	10½	4	A	S	....
400–260 hp per Engine														
Humble Pipe Line Co.	Chilton, Tex.	Oil	Pump	BuS	1	400	225	4	16¼	21	4	A	A	0.43
	Hearne, Tex.	Power	Gen	BuS	2	330	400	4	13	17	4	A	S	0.40
Sandersville	Georgia	Mun. Pwr.	Gen.	Sup	1	380	360	6	12½	15	4	A	S	....
Zeeland	Michigan	Mun. Pwr.	Gen.	F-M	1	375	300	5	14	17	2	A	S	....
Lex. Mill & Elevator Co.	Lexington, Neb.	Power	Alt.	Buc	1	375	360	5	13½	15½	4	A	S	0.40
Michigan Toledo Pipe Line	Chelsea, Mich.	Power	Gen.	Wor	1	375	327	5	13¼	17½	4	A	S	....
Cayuga Rock Salt Co.	Ludlowville, N. Y.	Power	Gen.	Buc	3	375	360	5	13½	15½	4	A	S	0.40
Strawberry Point	Iowa	Mun. Pwr.	Gen.	FIW	1	375	300	5	13¾	18	4	A	S	0.39
Parker	South Dakota	Mun. Pwr.	Gen.	FIW	1	375	300	5	13¾	18	4	A	S	0.39
C C Whitacre Co.	Chicago Hts., Ill.	Power	Alt.	Buc	1	375	360	5	13½	15½	4	A	S	0.40
					1	60	514	3	7⅛	10½	4	A	S	0.40
Indiana Pipeline Co.	.....	Oil	Pump	ALC	2	360	360	5	12½	18	4	A	S	....
Continental Pipe Line Co.	Orlando, Okla.	Oil	Pump	Sup	1	350	600	8	9	12	4	A	S	....
Parker Drilling Co.	Okla. City, Okla.	Power	Drill	Sup	2	350	600	8	9	12	4	A	S	....
Amer. Liberty Pipe Line Co.	Humble, Tex.	Oil	Pump	Sup	2	350	400	5	12½	15	4	A	S	....
		Aux.	Gen.	Sup	1	21	1200	2	4½	5¾	4	E	S	....
Lester F. Alexander	New Orleans, La.	Dredge	Pump	Sup	1	350	600	8	9	12	4	A	S	....
Pacific Metals Corp.	New York, N. Y.	Power	Gen.	Sup	1	350	600	8	9	12	4	A	S	....
Gulf Construct. Corp.	Ft. Myers, Fla.	Power	Gen.	Sup	1	350	600	8	9	12	4	A	S	....
Remington Sd. & Gravel Co.	Loveland, Ohio	Power	Gen.	Sup	1	350	600	8	9	12	4	A	S	....
Dooley Electric Corp.	New York, N. Y.	Power	Gen.	Sup	1	350	600	8	9	12	4	A	S	....
Texas Pipe Line Co.	Harvey, La.	Oil	Pump	Sup	1	305	570	8	9	12	4	A	C	....
Garnerville Holding Corp.	W. Haverstraw, N. Y.	Power	Gen.	V-S†	3	300	327	4	14¼	16½	2	A	S	0.42
Imperial Smelt. & Refining	Indio, Cal.	Power	Gen.	V-S†	1	300	327	4	14¼	16½	2	A	S	0.42
Lutesville Sand & Gr. Co.	Colfax, La.	Sand	Plant	Buc	1	300	360	4	13½	15½	4	A	S	0.40
Seaford	Delaware	Mun. Pwr.	Gen.	F-M	3	300	300	4	14	17	2	A	S	....
Lakeside Monarch	Delle, Utah	Power	Gen.	V-S†	1	300	327	4	14¼	16½	2	A	S	0.42
Watson Sand & Gravel Co.	Fluker, La.	Gravel	Pump	Buc	1	300	400	8	9½	14	4	A	S	0.40
E. S. Kiefer Tanning Co.	Grand Rapids, Mich.	Power	Alt.	Buc	1	300	400	8	9½	14	4	A	S	0.40
Berea Brick & Tile Co.	Berea, Ohio	Power	.....	B-M	1	300	277	4	14¼	18	2	A	S	0.40
Red Cedar Alfalfa Milling Co.	Williamstown, Mich.	Power	Mill	Buc	1	262½	400	7	9½	14	4	A	S	0.40

ABBREVIATIONS—ALC—American Locomotive Co, B-M—Ball Muncie, Buc—Buckeye, Bud—Buda, BuS—Busch-Sulzer, Cat—Caterpillar, C-B—Cooper-Bessemer, Ent—Enterprise Engine Co, FIW—Fulton Iron Works, FM—Fairbanks-Morse, HOR—Hooven, Owens, Rentschler, Mod—Modasg, Nor—Nordberg, PMC—Power Mfg Co, Sup—National Supply Co (Superior), VS—Venn-Severin, Wauk—Waukesha, WIW—Washington Iron Works, Wes—Western Engine Corp, Wor—Worthington. Add—addition, Alt.—alternator, Aux.—auxiliary, Comp.—compressor, C.S.—central station, Emer.—emergency, Gen.—generator, Irrig.—irrigation, Lt.—light, Pwr—power, Ref.—refrigeration.

Under fuel injection—A is air, S is solid, C is convertible to gas. Under starting method—A is air, E is electric, G is gasoline.

* Double acting. † Moderate-pressure oil engine. ‡ Hesselman engine.

Compiled by B E Sawyer, *Assistant Editor*

Owner	Location	Service	Equip. Driven	Engine Builder	No. Units	Hp Each	Rpm	No. Cyl	Cyl Bore	Cyl Stroke	Cycle	Starting Method	Fuel Injection	Fuel, lb per hp hr
Darlington Fireproofing Co	W. Darlington, Pa.	Power	Alt.	Buc	2	262½	400	7	9½	14	4	A	S	0.40
New Idea, Inc	Coldwater, Ohio	Power	Alt.	Buc	1	262½	400	7	9½	14	4	A	S	0.40
					2	225	400	6	9½	14	4	A	S	0.40
Natchitoches Oil Mill	Natchitoches, La.	Power	Alt.	Buc	1	262½	400	7	9½	14	4	A	S	0.40
Israel Bros. Co	Dayton, Ohio	Power	Shaft	Sup	1	260	600	6	9	12	4	A	S	....
McQueen & Clevenger	Hobbs, New Mex.	Power	Drill	Sup	2	360	600	6	9	12	4	A	S	....
		Aux.	Gen.	Sup	1	21	1200	2	4½	5¾	4	E	S	....
Gibsonburg Lime Prod. Co	Gibsonburg, Ohio	Power	Gen. Crusher	Sup	1	260	600	6	9	12	4	A	S‖	....
Phillips Petroleum Co	Susank, Kan.	Power	Gen.	Sup	1	260	600	6	9	12	4	A	S	....
					2	240	600	6	9	12	4	A	C	....
Dunn & Baker	Klamath, Calif.	Rock	Crusher	Ent	1	260	500	6	10	13	4	A	S	0.39
Carl Short	Eunice, Okla.	Power	Drill	Sup	1	260	600	6	9	12	4	A	S	....
	Eunice, N. Mex.	Power	Drill	Sup	1	175	600	4	9	12	4	A	S	....
	Eunice, N. Mex.	Power	Comp.	Sup	1	21	1200	2	4½	5¾	4	E	S	....
250–160 hp per Engine														
Nat'l Supply Co	Springfield, Ohio	Power	Gen.	Sup	1	250	360	5	11½	14	4	A	S	....
Sinclair Refining Co	Edmond, Okla.	Oil	Pump	Sup	1	240	600	6	9	12	4	A	C	....
Pacific Bridge Co	Mare Isl., Calif.	Water	Pump	Ent	1	240	514	6	9½	11½	4	A	S	0.39
Carlyle Mining Co	Beverly Hills, Calif.	Power	Gen.	F-M	1	225	300	3	14	17	2	A	S	0.38
Producers Mines, Inc	Chloride, Ariz.	Power	Gen.	F-M	1	225	300	3	14	17	2	A	S	0.38
Fairhope	Alabama	Mun. Pwr.	Gen.	F-M	1	225	300	3	14	17	2	A	S	0.38
Kaplan	Louisiana	Mun. Pwr.	Gen.	F-M	1	225	300	3	14	17	2	A	S	0.38
Imperial Metal Prod. Co	Grand Rapids, Mich.	Power	Alt.	Buc	1	225	400	6	9½	14	4	A	S	0.40
War Dept., U. S. Engrs	Fort Stotsenburg, P. I.	Lt. & Pwr.	Gen.	FIW	1	225	300	3	14	18	4	A	S	0.39
Julian & Kokenge Co	Columbus, Ohio	Power	Alt.	Buc	3	225	400	6	9½	14	4	A	S	0.40
Bountiful City Corp	Bountiful, Utah	Power	Alt.	Buc	1	225	400	6	9½	14	4	A	S	0.40
War Dept., U. S. Engrs	Fort Mills, P. I.	Ref.	Comp.	FIW	1	225	300	3	14	18	4	A	S	0.39
Grand Rapids Fibre Cord Co	Grand Rapids, Mich.	Power	Alt.	Buc	1	225	400	6	9½	14	4	A	S	0.40
Green Bag Cement Co	Lawton, Ky.	Power	Alt.	Buc	1	225	400	6	9½	14	4	A	S	0.40
Pine River Power	Durango, Colo.	Power	Gen.	V-S†	1	215	327	3	14¼	16½	2	A	S	0.42
					1	140	327	2	14¼	16½	2	A	S	0.43
Alaska Pub. Utilities Co	Cardova, Alaska	Power	Gen.	Sup	1	215	600	5	9	12	4	A	S	....
Univ. Insulation Co	Libby, Mont.	Power	Gen.	Sup	1	215	600	5	9	12	4	A	S	....
Humble Pipe Line Co	Benavides, Tex.	Oil	Pump	Wor	1	205	300	3	13¼	17½	4	A	S	....
					1	180	600	6	8	10½	4	A	S	....
Leo Earl	King City, Cal.	Irrig.	Pump	V-S†	1	200	327	3	14¼	16½	2	A	S	0.43
Pacific American Fisheries	Washington	Power	Gen.	WIW	1	200	327	4	11½	15	4	A	S	0.42
Hirst Chichagof Mining Co	Alaska	Power	Gen.	WIW	1	200	327	4	11½	15	4	A	S	0.42
Owl Creek Irrig. Dist	Thermopolis, Wyo.	Irrig.	Pump	Sup	2	192	525	5	9	12	4	A	S	....
Alwine Brick Co	New Oxford, Pa.	Power	Alt.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
					1	40	514	2	7⅛	10½	4	A	S	0.40
Owensboro Forging Co	Owensboro, Ky.	Power	Alt.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
Cranberry Mfg. Co	Galax, Va.	Power	Alt.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
A. H. Smith Sand & Gr. Co	Branchville, Md.	Power	Alt.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
Arabi Packing Co	Arabi, La.	Power	Alt.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
Heckle & Kellogg	Cape Charles, Va.	Ref.	Comp.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
Galion Ice & Fuel Co	Galion, Ohio	Ref.	Comp.	Buc	1	187½	400	5	9½	14	4	A	S	0.40
Milford Water Co	Milford, Mass.	Water	Pump	Wor	1	180	600	6	8	10½	4	A	S	....
A. I. Namm & Son	Brooklyn, N. Y.	Power	Gen.	Wor	1	180	600	6	8	10½	4	A	S	....
Morgan Concentrating Co	Arizona	.....	.....	Wes	1	180	900	6	7¼	8	4	A	S	0.42
Pyramid Granite Co	St. Cloud, Minn.	Power	Gen.	F-M	1	180	360	3	12	15	2	A	S	0.38
Mankato Brewing Co	Mankato, Minn.	Power	Gen.	F-M	1	180	360	3	12	15	2	A	S	0.38
St. Genevieve Lime & Quarry	Mosher, Mo.	Air	Comp.	Sup	1	180	257	4	12½	15	4	A	S	....
Carthage Crushed Stone Co	Carthage, Mo.	Power	Shaft	Sup	1	175	600	4	9	12	4	A	S	....
Continental Pipe Line Co	Crescent, Okla.	Oil	Pump	Sup	1	175	600	4	9	12	4	A	S	....
Loffland Bros Co	Okla. City, Okla.	Power	Drill	Sup	1	175	600	4	9	12	4	A	S	....
New Mechanics Laundry	Chicago, Ill.	Power	Gen.	Wauk‡	1	175	900	6	7	7	4	E	S	0.52
Verona Sand & Gravel Co	Verona, Wis.	Gravel	Plant	Wauk‡	1	175	900	6	7	7	4	E	S	0.52
Constantine	Michigan	Mun. Pwr.	Gen.	B-M	3	165	327	3	13	16	2	A	S	0.41
Delaware Clay Co	Delaware, Ohio	Clay	.....	PMC	1	165	230	1	22	24	2	A	S	....
Raabe Stone Co	Cloverdale, Ohio	Stone	.....	PMC	1	165	210	1	22	24	2	A	S	....
T. J. Smith	Arizona	Water	Pump	Ent	1	165	640	6	8	10	4	A	S	0.39
Maryland Tri County Coop. Assn	Popes Creek, Md.	Pwr., Lt.	Gen.	B-M	3	165	327	3	13	16	2	A	S	0.41
McClellan & Campbell	Bowling Green, Ky.	Rock	Crusher	Cat	1	160	850	8	5¾	8	4	G	S	0.43
150–110 hp per Engine														
Piqua Milling Co	Piqua, Ohio	Flour	Mill	B-M	1	150	277	2	14¼	18	2	A	S	0.40
Delaney & Co., Inc	Philadelphia, Pa.	Power	Gen.	Sup	1	150	514	4	9	12	4	A	S	....
Simonds Saw & Steel Co	Fitchburg, Mass.	Power	Gen.	Sup	1	150	514	4	9	12	4	A	S	....
W. H. Adams	Atlantic Beach, Fla.	Power	Alt.	Buc	2	150	400	4	9½	14	4	A	S	0.40
North Pole Ice Co	Uniontown, Pa.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Vulcan Rail & Const. Co	Maspeth, N. Y.	Power	Gen.	Wor	1	150	600	5	8	10½	4	A	S	....
Seward	Alaska	Power	Gen.	Wor	3	150	600	5	8	10½	4	A	S	....
Buoyrus Ice & C. S. Co	Buoyrus, Ohio	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Buck Hill Falls Co	Buck Hill Falls, Pa.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Boeving Bros. Cotton Co	White Oak, Mo.	Cotton	Gin	PMC	1	150	210	1	22	24	2	A	S	....
Jahncke Service, Inc	New Orleans, La.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Mitchell Battery Co	Minneapolis, Minn.	Power	Gen.	F-M	1	150	300	2	14	17	2	A	S‖	0.38
Mullen	Nebraska	Mun. Pwr.	Gen.	F-M	1	150	300	2	14	17	2	A	S‖	0.38
U. S. Envelope Co	Rockville, Conn.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S‖	0.40
Flat Rock Clay Prod. Co	Flat Rock, Mich.	Brick	Plant	Buc	1	150	400	4	9½	14	4	A	S	0.40
Citizen's Ice Co	Covington, Tenn.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Calvert Farms, Inc	Richmond, Mo.	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
Kuenzli Quarries Co., Inc	Upper Sandusky, Ohio	Power	Alt.	Buc	1	150	400	4	9½	14	4	A	S	0.40
F. N. Hayes	Iota, La.	Irrig.	Pump	B-M	1	150	277	2	14¼	18	2	A	S	0.40
Hamie Guidrey	Basile, La.	Irrig.	Pump	B-M	1	150	277	2	14¼	18	2	A	S	0.40
C. O. Lantz	Riverside, Cal.	Irrig.	Pump	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
	Moreno, Cal.	Irrig.	Pump	V-S†	1	100	360	2	12¼	13½	2	A	S	0.43
A. E. Bell Corp	Bel Aire, Cal.	Irrig.	Pump	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
					1	100	360	2	12¼	13½	2	A	S	0.43
J. J. Kovacevich	Arvin, Cal.	Irrig.	Pump	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
St. Elmo Brick Plant	St. Elmo, Ill.	Brick	Mach'y	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
					1	30	400	1	10½	12	2	A	S	0.45
Wimmer Mine	Rockville, Ind.	Power	Gen.	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
Kingsbury Metal	Chicago, Ill.	Air	Comp.	V-S†	1	140	327	2	14¼	16½	2	A	S	0.43
Gillespie Land & Irrig. Co	Gila Bend, Ariz.	Irrig.	Pump	Sup	4	130	600	3	9	12	4	A	S	....
Gulf Bldg	Pittsburgh, Pa.	Emer.	Gen.	Cat	2	125	900	6	5¾	8	4	G	S	0.43
Hudson-Burr	Bloomington, Ill.	Drain.	Pump	V-S†	1	125	290	2	14¼	16½	2	A	S	0.43
Dixson Ice Co	Greensboro, N. C.	Ref.	Comp.	Cat	1	125	850	6	5¾	8	4	G	S	0.42
Livermore Hospital	Livermore, Calif.	Water	Pump	Ent	1	125	400	4	9½	11½	4	A	S	0 39
Buzick-Nelms Gin Co	Caraway, Kan.	Cotton	Gin	PMC	1	125	210	1	20	24	2	A	S	....
W. H. McClure	Centerville, Ark.	Cotton	Gin	PMC	1	125	245	1	18½	24	2	A	S	....
Clay County Cotton Co	Corning, Ark.	Gravel	Crusher	PMC	1	125	225	1	20	24	2	A	S	....
Film Center	New York, N. Y.	Pwr. & Lt.	Gen.	Bud	4	122	720	6	6½	8¾	4	E	S	....
Cushing Ice Co	Cushing, Okla.	Ref.	Comp.	F-M	1	120	360	2	12	15	2	A	S	0.40
Round Valley Lt. & Pwr. Co	Springerville, Ariz.	C.S. Pwr.	Gen.	F-M	1	120	360	2	12	15	2	A	S	0.40
Boyd Gin Co	Boyd, Ala.	Cotton	Gin	F-M	1	120	360	2	12	15	2	A	S	0.40
Crystal Ice & Coal Co	Plainfield, N. J.	Ref.	Comp.	F-M	1	120	360	2	12	15	2	A	S	0.40
Whiting	Iowa	Mun. Pwr.	Gen.	F-M	1	120	360	2	12	15	2	A	S	0.40
Mahoning Mining Co	Elizabethtown, Ill.	Power	Gen.	F-M	1	120	360	2	12	15	2	A	S	0.40
Peoples Gin Co	Wintersville, Miss.	Cotton	Gin	F-M	1	120	360	2	12	15	2	A	S	0.40
Bryant Gin Co	Leachville, Ark.	Cotton	Gin	F-M	1	120	360	2	12	15	2	A	S	0.40
Cal. Inst. Technology	Pasadena, Calif.	Power	Gen.	Ent	2	120	600	4	8	10	4	A	S	0.39
Symington Gould Corp	Rochester, N. Y.	Power	Gen.	Wor	1	120	600	4	8	10½	4	A	S	....
Viking Tool & Machine Co	Belleville, N. J.	Power	Gen.	Mod	1	120	600	4	6	10¾	2	..	..	....
Parkhill Dredging Co	Jacksonville, Fla.	Power	Gen.	Sup	1	115	720	5	7	9	4	A	S	....
Cincinnati Water Works	Cincinnati, Ohio	Power	Gen.	Sup	1	115	720	5	7	9	4	A	S	....
S. S. Corrug. Paper Mchry. Co	Brooklyn, N. Y.	Power	Gen.	Sup	1	115	720	5	7	9	4	A	S	....
Hoegner & Cantieny	Lima, Ohio	Power	Alt.	Buc	1	112½	400	3	9½	14	4	A	S	0.40
Atkinson Ice Co	Bicknell, Ind.	Ref.	Comp.	Buc	1	112½	400	3	9½	14	4	A	S	0.40
R. H. Adams Ice Co	Gastonia, N. C.	Power	Alt.	Buc	1	112½	400	3	9½	14	4	A	S	0.40
Southern Flour Mills	Albermarle, N. C.	Power	Alt.	Buc	1	112½	400	3	9½	14	4	A	S	0.40
General Ore Reduction Co	Arizona	.....	.....	Wes	1	110	330	4	9	12½	4	A	S	0.42

Diesel Installations Under 100 Hp

Owner	Location	Equipt. Driven	Engine Builder	No. Units	Hp Each	Rpm	No. Cyl	Bore	Stroke	Starting Method
Trojan Laundry,	Chicago, Ill.	Gen.	Wauk‡	1	100	1000	4	6½	8	E
McDonald Dredg. Co,	Elkhorn, Wis.	Pump	Wauk‡	1	100	1000	4	6½	8	E
D E Ryan & Sons,	Janesville, Wis.	Crusher	Wauk‡	2	100	1000	4	6½	8	E
Wis. Fndry. & M. Co,	Madison, Wis.	Crusher	Wauk‡	1	100	1000	4	6½	8	E
		Comp.	Wauk‡	3	80	1000	4	6	6½	E
Wilson M & S Co,	Lexington, Ky.	Crusher	Wauk‡	2	100	1000	4	6½	8	E
Thorman Rosholt Co,	Minn., Minn.	.....	Wauk‡	1	100	1000	4	6½	8	E
R S McLoughlin,	Bloomington, Ill.	Mill	Wauk‡	1	100	1000	4	6½	8	E
Boyar-Schultz,	Chicago, Ill.	Gen.	V-S†	1	100*	327	2	12¾	13½	A
Union Theo. Seminary,	New York	Gen.	V-S†	2	100*	360	2	12¼	13½	A
Marion Cot. Oil Co,	Marion, S. C.	Gin	Cat	2	100	850	6	5¼	8	G
R J Ederer Co,	Chicago, Ill.	Gen.	V-S†	1	100*	327	2	12¼	13½	A
				1	60*	400	2	10½	12	A
W W Hartman,	Las Vegas, Ariz.	Gen.	V-S†	1	100*	360	2	12¼	13½	A
New Gin Co,	Pascola, Mo.	Gin	PMC	1	100*	225	1	18½	24	A
Bertig Co.,	Paragould, Ark.	Gin	PMC	1	100*	225	1	18	24	A
G Kellett & Sons,	New Orleans, La.	Alt.	Buc	1	100	514	5	7⅛	10½	A
George E Judd,	Ft. Myers, Fla.	Gen.	Sup	1	100	600	5	7	9	A
Hope Brick Works,	Hope, Ark.	Alt.	Buc	1	100	514	5	7⅛	10½	A
Bird & Stephens,	Kennett, Mo.	Gin	PMC	1	100*	210	1	18	24	A
John LaHaye,	Ville Platte, La.	Pump	B-M	1	90*	240	1	15½	22	A
Martin Langley,	Elton, La.	Pump	B-M	1	90*	240	1	15½	22	A
Jap. Morris,	Eunice, La.	Pump	B-M	1	90*	240	1	15½	22	A
N Webster Ice Co,	N Webster, Ind.	Comp.	B-M	1	90*	240	1	15½	22	A
Uhl-Sneider M. Co,	Connersville, Ind.	Mill	B-M	1	90*	240	1	15½	22	A
Metal Weld, Inc,	Philadelphia, Pa.	Comp.	Wor	1	90	600	3	8	10½	A
Thomson Electric Co,	Wash., D. C.	Gen.	Wor	2	90	600	3	8	10½	A
Haigler,	Nebraska	Gen.	F-M	1	90*	450	3	8¾	10½	A
				1	60*	450	2	8¾	10½	A
Rainbow Tavern,	Soda Springs, Calif.	Gen.	Ent	1	90	600	3	8	10	A
Com'wealth Chem. Co,	Br'klyn, N. Y.	Gen.	Mod	3	90*	600	3	6	10¾	..
Chas Cooper & Co,	Los Angeles, Calif.	.....	PMC	1	85*	300	1	15	20	A
Farmers Gin Co, Inc,	Colfax, La.	Gin	PMC	1	85*	300	1	15	20	A
241 Central Park W,	New York, N. Y.	Gen.	Bud	3	85	900	6	5¼	7	E
W L Matteson,	Foreman, Ark.	Gin	PMC	1	85*	300	1	15	20	A
11 Park Place,	New York, N. Y.	Gen.	Bud	4	85	900	6	5¼	7	E
Perry & Holmes,	Bay, Ark.	Gin	PMC	1	85*	300	1	15	20	A
55 Central Park W,	New York, N. Y.	Gen.	Bud	3	85	900	6	5¼	7	E
Phoenix Gin Co,	Batesville, Ark.	Gin	PMC	1	85*	300	1	15	20	A
Oil Trough Gin Co,	Oil Trough, Ark.	Gin	PMC	1	85*	300	1	15	20	A
A J Simmons,	Booneville, Ark.	Gin	PMC	1	85*	300	1	15	20	A

84–62 hp per Engine

A Stralla,	Beverly Hills, Calif.	Gen.	Sup	2	84	1200	8	4½	5¾	E
Oxford Co,	Oxford, Pa.	Gen.	Sup	1	84	1200	8	4½	5¾	E
Upton Cold Stor. Co,	Rochester, N. Y.	Gen.	Sup	2	84	1200	8	4½	5¾	E
W S & Pitman Lndry,	Pitman, N. J.	Gen.	Sup	1	84	1200	8	4½	5¾	E
Drilling & Explo. Co,	Odessa, Tex.	Gen.	Sup	4	84	1200	8	4½	5¾	E
S & M Drilling Co,	Pinewald, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
Kirkpatrick & Lamb,	Big Sprgs, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
Ohio Oil Co,	Casper, Wyo.	Drill	Sup	1	84	1200	8	4½	5¾	E
Beams & Tunney,	Abilene, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
H M Drilling Co,	Artesia, N. Mex.	Drill	Sup	1	84	1200	8	4½	5¾	E
Parker Drilling Co,	Seminole, Tex.	Drill	Sup	2	84	1200	8	4½	5¾	E
				2	21	1200	2	4½	5¾	E
Emperor Oil Co,	Artesia, N. Mex.	Drill	Sup	1	84	1200	8	4½	5¾	E
McQueen & Stout,	Midland, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
Nat. Supply Co,	Odessa, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
	Tulsa, Okla.	Drill	Sup	2	84	1200	8	4½	5¾	E
Nat. Supply Co,	McCamey, Tex.	Drill	Sup	1	84	1200	8	4½	5¾	E
				2	62	1200	6	4½	5¾	E
Std Oil of N. J.	New York, N. Y.	Gen.	Sup	1	84	1200	8	4½	5¾	E
	Baltimore, Md.	Pump	Sup	1	62	1200	6	4½	5¾	E
J Pitts & Son,	Casco, Me.	Saw	Cat	1	80	850	4	5¾	8	G
HomeCityI&CCo,	Hattiesburg, Miss.	Shaft	Supx	1	80	400	3	9	12	A
Robert H. Giere,	Coldwater, Ohio.	Alt.	Buc	1	80	514	4	7⅛	10½	A
Central Laundry,	Sheboygan, Wis.	Alt.	Buc	1	80	514	4	7⅛	10½	A
O Rock Asphalt Co,	Hillsboro, Ohio.	.....	PMC	1	80*	277	1	15	20	A
G R Creamery Co,	Grand R, Minn.	Alt.	Buc	1	80	514	4	7⅛	10½	A
R G Moeller Co,	Detroit, Mich.	Mill	Wauk‡	1	80	1000	4	6	6½	E
Seaman Ice Co,	New Lexington, Ohio.	Alt.	Buc	1	80	514	4	7⅛	10½	A
Mech. Equip. Co,	New Orleans, La.	Pump	Wauk‡	5	75	1000	4	6	6½	E
Monticello Ice Co,	Monticello, N. J.	Comp.	Wor	1	75	514	3	8	10½	A
New Richmond Mills,	Cadotte, Wis.	Mill	Wauk‡	1	75	1000	4	6	6½	E
Cumb. M. Co,	Cumberland, Wis.	Mill	Wauk‡	1	75	1000	4	6	6½	E
Gulf Oil Co,	Camden, N. J.	Pump	Sup	2	68	720	3	7	9	A
Brunswick Home,	Amityville, L. I.	Gen.	Rus	1	66	265	1	12½	22	A
			Sup	1	62	1200	6	4½	5¾	E
Folmer Ice Cream Co,	Hanover, Pa.	Gen.	Sup	1	65	700	3	7	9	A
Spedden Shipbldg Co,	Baltimore, Md.	Pump	Sup	2	62	1200	6	4½	5¾	E
Socony-Vac Oil Co,	New York, N. Y.	Gen.	Sup	2	62	1200	6	4½	5¾	E
				1	21	1200	2	4½	5¾	E
Campbell M. Co,	San Diego, Calif.	Gen.	Sup	4	62	1200	6	4½	5¾	E
				1	42	1200	4	4½	5¾	E
Standard Oil Co,	Cleveland, Ohio.	Pump	Sup	1	62	1200	6	4½	5¾	E
				1	42	1200	4	4½	5¾	E
Amer. Barge Line Co,	Louisville, Ky.	Gen.	Sup	1	62	1200	6	4½	5¾	E
Southport Transit Co,	Houston, Tex.	Pump	Sup	1	62	1200	6	4½	5¾	E
Lewis Adams,	Wilmington, Vt.	Saw	Sup	1	62	1200	6	4½	5¾	E
Millside Farms,	Riverside, N. J.	Gen.	Sup	2	62	1200	6	4½	5¾	E
Gulf Oil Corp,	New York, N. Y.	Pump	Sup	4	62	1200	6	4½	5¾	E
John Strobridge,	Philadelphia, Pa.	Pump	Sup	1	62	1200	6	4½	5¾	E
Giant Tiger Corp,	Camden, N. J.	Gen.	Sup	2	62	1200	6	4½	5¾	E
Main Block Serv,	Paterson, N. J.	Gen.	Sup	3	62	1200	6	4½	5¾	E
Maritime Oil Co,	Houston, Tex.	Pump	Sup	1	62	1200	6	4½	5¾	E
Capitol Laundry Co,	Trenton, N. J.	Gen.	Sup	1	62	1200	6	4½	5¾	E
I Zellerbach,	San Francisco, Calif.	Gen.	Sup	1	62	1200	6	4½	5¾	E
Del Dredging Co,	Wilmington, Del.	Gen.	Sup	1	62	1200	6	4½	5¾	E
Red Lion Market,	Queens, L. I., N. Y.	Gen.	Sup	1	62	1200	6	4½	5¾	E
Cleanart, Inc,	Yonkers, N. Y.	Gen.	Sup	1	62	1200	6	4½	5¾	E
Gulf Oil Corp,	New York, N. Y.	Gen.	Sup	1	62	1200	6	4½	5¾	E
U S Engrs,	Kansas City, Mo.	Gen.	Sup	1	62	1200	6	4½	5¾	E
J. McWilliams Blue Lines,	S. I., N. Y.	Pump	Sup	2	62	1200	6	4½	5¾	E
Coop Elect'plating Co,	Jer. City, N. J.	.....	Sup	1	62	1200	6	4½	5¾	E
W H Costenbader,	Perryville, Pa.	Comp.	Sup	1	62	1200	6	4½	5¾	E
Cardinal Oil Co,	McCamey, Tex	Drill	Sup	1	62	1200	6	4½	5¾	E
George Callahan,	Albany, N. Mex.	Drill	Sup	1	62	1200	6	4½	5¾	E
Nat. Supply Co,	Houston, Tex.	Drill	Sup	1	62	1200	6	4½	5¾	E
	Monahans, Tex.	Drill	Sup	2	62	1200	6	4½	5¾	E

60–30 hp per Engine

Howard Rose,	Hemet, Cal.	Pump	V-S†	1	60*	300	1	14¼	16½	A
K Shabazian,	N. Bergen, N. J.	Gen.	V-S†	1	60*	400	2	10½	12	A
Ice Service Co,	Denton, Md.	Comp.	F-M	1	60*	360	1	12	15	A
Harvey Allen,	San Diego, Cal.	Pump	V-S†	1	60*	300	1	12¾	16½	A
Charles Foti,	St. Martinville, La.	Alt.	Buc	1	60	514	3	7⅛	10½	A
L S Anderson,	Statesboro, Ga.	Gin	V-S†	1	60*	277	1	14¼	16½	A
F Alexic,	Bakersfield, Cal.	Pump	V-S†	1	60*	277	1	14¼	16½	A
King Farm Dairy,	Rockford, Ill.	Comp.	V-S†	1	60*	400	2	10½	12	A
I R Carter,	Bridgeport, Conn.	Gen.	V-S†	1	60*	360	2	10½	12	A
Annie Rouse,	Bell, Cal.	Pump	V-S†	1	60*	300	1	14¼	16½	A
O T Kelly,	Placentia, Cal.	Pump	V-S†	1	60*	300	1	14¼	16½	A
Denver & R G R R,	Denver, Colo.	Gen.	Wor	1	60	600	2	8	10½	A
G Zaninovich,	Dinuba, Cal.	Pump	V-S†	1	60*	277	1	14¼	16½	A
Essex Dairy,	Irvington, N. J.	Comp.	V-S†	1	60*	277	1	14¼	16½	A
Theune Bros Hatch.,	Oostburg, Wis.	Alt.	Buc	1	60	514	3	7⅛	10½	A
E B Gilmore,	Los Angeles, Cal.	Pump	V-S†	1	60*	277	1	14¼	16½	A
D Radovich,	Delano, Cal.	Pump	V-S†	1	60*	277	1	14¼	16½	A
Pearl Riv Cream Co,	Columbia, Miss.	Comp.	F-M	1	60*	360	1	12	15	A
Martinsville Ice Co,	Martinsville, Va.	Alt.	Buc	1	60	514	3	7⅛	10½	A
A E Wenning,	New Salisbury, Ind.	Alt.	Buc	1	60	514	3	7⅛	10½	A
Morton,	Mississippi	Pump	Cat	1	60	850	3	5¾	8	G
Samson Ice Co,	Samson, Ala.	Comp.	F-M	1	60*	360	1	12	15	A
Home Ice & Dairy,	Georgetown, Ky.	Comp.	F-M	1	60*	450	2	8¾	10½	A
Country Feed Mills,	Vandalia, O.	Shaft	F-M	1	60*	450	2	8¾	10½	A
Pete Ciabarri,	Los Angeles, Calif.	Gen.	F-M	1	60*	450	2	8¾	10½	A
Vic Bracke,	Peach Springs, Ariz.	Gen.	F-M	1	60*	450	2	8¾	10½	A
Garden City Ga'ge,	Garden City, L. I.	Gen.	Rus	1	57	275	1	11¾	21	A
Gutfreund Mkt,	New York, N. Y.	Gen.	Rus	1	57	275	1	11¾	21	A
				1	34	310	1	9¼	17½	A
Cascade Laundry,	Brooklyn, N. Y.	Gen.	Bud	1	55	1500	6	4	5½	E
Terminal Grille,	New Brunswick, N. J.	Gen.	Bud	1	53	1200	6	4½	5½	E
Hensel Snd. & Gr. Co,	New Phila, O.	Crusher	PMC	1	50*	300	1	13	16	A
Morris Bros Co,	N. Chelmford, Mass.	.....	PMC	1	50*	300	1	13	16	A
Kohler,	Missouri	Gen.	Wauk	1	50	1200	4	4⅝	5¼	E
F E Wyman,	Arlington, Mass.	Gen.	Bro	1	50*	500	2	6⅞	9¼	A
W R Hill,	Frankenmuth, Mich.	Mill	Cat	1	44	1400	4	4¼	5½	G
W N Broughton,	London, Ky.	Saw	Cat	1	44	1400	4	4¼	5½	G
F D Costers,	New York, N. Y.	Gen.	Sup	1	42	1200	4	4½	5¾	E
Zoleggi Bros,	San Diego, Cal.	Gen.	Sup	1	42	1200	4	4½	5¾	E
				1	21	1200	2	4½	5¾	E
Millbury Mach Co,	Millbury, Mass.	Gen.	Sup	1	42	1200	4	4½	5¾	E
Alex Bernard,	New York, N. Y.	Gen.	Sup	1	42	1200	4	4½	5¾	E
Perry & Drake,	Seattle, Wash.	Gen.	Sup	2	42	1200	4	4½	5¾	E
Max C Fleishman,	Glenbrook, Nev.	Gen.	Sup	1	42	1200	4	4½	5¾	E
Dravo Corp,	Pittsburgh, Pa.	Gen.	Sup	2	42	1200	4	4½	5¾	E
US Pub Health Serv,	New York, N. Y.	Gen.	Sup	1	42	1200	4	4½	5¾	E
Arundel Corp,	Baltimore, Md.	Gen.	Sup	1	42	1200	4	4½	5¾	E
MillerLand& StockCo,	Parkman, Wyo.	Gen.	Sup	1	42	1200	4	4½	5¾	E
S & L Massa,	Los Angeles, Cal.	Gen.	Sup	2	42	1200	4	4½	5¾	E
Condenser Prod. Co,	Chicago, Ill.	Gen.	F-M	1	40	1200	4	4¼	6	E
E P Waggoner,	Vernon, Tex.	Gen.	F-M	1	40	1200	4	4¼	6	E
Fla. Military Acad,	St. Petersburg, Fla.	Gen.	F-M	1	40	1200	4	4¼	6	E
Dixon Ice Co,	Americus, Ga.	Comp.	V-S†	1	40*	330	1	12¾	13½	A
Butler Ice Co,	Butler, Ga.	Comp.	V-S†	1	40*	300	1	12¾	13½	A
Wis. Storage Battery Co,	Racine, Wis.	Gen.	F-M	1	40	1200	4	4¼	6	E
Pecos Ice Co,	Ft. Worth, Tex.	Comp.	F-M	1	40	1200	4	4¼	6	E
Kenwood Ap'ments,	Great Neck, L. I.	Gen.	Sch	2	40	900	3	5⅛	7⅛	..
Tork Elect Mfg Co,	Cleveland, Ohio.	Gen.	F-M	1	40	1200	4	4¼	6	E
Sevison Magneto Co,	Toledo, Ohio.	Gen.	F-M	1	40	1200	4	4¼	6	E
Nylen Products Co,	St. Joe, Mich.	Shaft	F-M	1	40	1200	4	4¼	6	E
Rudolph Wind,	Babylon, L.I.	Gen.	Sch	2	40	900	3	5⅛	7⅛	..
C C Millard,	Mt. Gilead, Ohio.	.....	PMC	1	35*	300	1	11½	16	A
Showboat,	Brooklyn, N. Y.	Gen.	Rus	1	34	310	1	9¼	17½	A
DoubleS&SRadioStore,	Suffern, N Y.	Gen.	V-S†	1	30*	360	1	10½	12	A
George Briggs,	Charleston, Ill.	Comp.	V-S†	1	30*	400	1	10½	12	A
Danube Oil Co,	Borger, Tex.	Gen.	V-S†	1	30*	400	1	10½	12	A
J Kiss & Son,	Guttenberg, N. J.	Gen.	V-S†	1	30*	400	1	10½	12	A
J B Sims Motor Co,	Hoopeston, Ill.	Gen.	V-S†	1	30*	400	1	10½	12	A
W W Compton,	Datelan, Ariz.	Pump	V-S†	1	30*	360	1	10½	12	A
George Wagner,	Hillside, N. J.	Gen.	V-S†	1	30*	400	1	10½	12	A

Under 30 hp per Engine

Royal Route Co,	Natchez, Miss.	Gen.	Lis	2	27	1000	3	5½	4	H
Tonapath&TideRR,	Los Angeles, Cal.	.....	Wor	1	25	514	1	8	10½	A
Red River Ice Co,	Harwichport, Mass.	Comp.	Rus	1	24	345	1	8	15½	A
Sturdy Bros,	Mass.	Gen.	Rus	1	22	345	1	7¾	15½	A
Prospect Poultry Farm,	Dorothy, N.J.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Dunellin Diner,	Dunellin, N. J.	Gen.	Sup	1	21	1200	2	4½	5¾	E
A B Patterson,	New Orleans, La.	Gen.	Sup	1	21	1200	2	4½	5¾	E
R P Scripps,	San Diego, Cal.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Morgan Adams,	Los Angeles, Calif.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Parker Drilling Co,	Vernon, Tex.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Phillips Petroleum Co,	Vernon, Tex.	Gen.	Sup	1	21	1200	2	4½	5¾	E
B T Dobson,	New Bedford, Mass.	Gen.	Sup	2	21	1200	2	4½	5¾	E
National Sup Co,	Russell, Tex.	Gen.	Sup	1	21	1200	2	4½	5¾	E
	Okla. City, Okla.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Campbell Mach. Co,	San Diego, Cal.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Nat'l Pet Trans Co,	New York, N. Y.	Gen.	Sup	1	21	1200	2	4½	5¾	E
U S Dept Commerce,	Wash, D. C.	Gen.	Sup	2	21	1200	2	4½	5¾	E
Simpson Invest Co,	Seattle, Wash.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Prince Bros Drilling Co,	Seagrave, Tex.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Continental Oil Co,	Ponca City, Okla.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Rochester Tel Co,	Rochester, N. Y.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Poster Process Co,	Maywood, Ill.	Gen.	Sup	1	21	1200	2	4½	5¾	E
Pine Mt. School,	Pine Mt, Ky.	Gen.	F-M	1	20	1200	2	4¼	6	E
Ruth & Kramer,	Chamita, N. Mex.	Gen.	F-M	1	20	1200	2	4¼	6	E
D & H Scoville,	Higganum, Conn.	Gen.	F-M	1	20	1200	2	4¼	6	E
Columbia Const. Co,	Westport, Wash.	Gen.	F-M	1	20	1200	2	4¼	6	E
C A McKay,	Buford, Ga.	Gen.	F-M	1	20	1200	2	4¼	6	E
C Kirk Hillman Co,	Seattle, Wash.	Shaft	F-M	2	20	1200	2	4¼	6	E
C P Case,	Hartford, Conn.	Gen.	Lis	1	18	1000	2	4½	5½	H
H VanDorp,	Pinetown, N C.	Gen.	Rus	1	16	‡360	1	7¾	13½	H
Wharf Mach & E Co,	Boston, Mass.	Gen.	Lis	2	16	1000	2	4½	4⅜	H
Oak Ridge Garage,	Tuckahoe, N. Y.	Gen.	Rus	1	13	360	1	7	13½	H
Frank Crook Inc,	Pawtucket, R. I.	Shaft	F-M	1	10	1200	1	4¼	6	E
John Hopkins,	Cambridge, Md.	Gen.	Lis	1	10	600	2	4½	5½	H
C K Marvin,	Port Jefferson, L. I.	Gen.	Sch	1	10	900	4	4⅝	6⅜	..
Lectro Engrg Corp,	Savannah, Ga.	Gen.	Lis	2	5	600	1	4½	5½	H
A A Johnson,	Wilmington, Cal.	Gen.	Lis	2	5	600	1	4½	5½	H
Diesel Electric Corp,	Savannah, Ga.	Gen.	Lis	2	5	600	1	4½	5½	H
Diesel Power Corp,	Springfield, Mass.	Gen.	Lis	1	3	600	1	3⅜	5½	H
La. Materials Corp,	New Orleans, La.	Gen.	Lis	1	3	600	1	3⅜	5½	H
Catholic U,	Washington, D. C.	Gen.	Lis	1	3	600	1	3⅜	5½	H

ABBREVIATIONS—B-M—Ball-Muncie, Bro—Bronander, Buc—Buckeye, Bud—Buda, Cat—Caterpillar, F-M—Fairbanks-Morse, Lis—Lister, Mod—Modaag, PMC—Power Mfg Co, Rus—Ruston, Sch—Schleuter, Sup—National Supply Co (Superior), V-S—Venn-Severin, Wauk—Waukesha, Wor—Worthington.

Under starting method—A is air, E is electric, G is gasoline, H is hand.

† Moderate-pressure oil engine.
* 2-cycle engines.
‡ Hesselman oil engine.
x Convertible to gas.

Oil & Gas Power

Typical Gas Engines

153 Plants, 324 Engines

Installed since January 1, 1936

Compiled by B E Sawyer, *Assistant Editor*

Power, June, 1938—Page 85.

Owner	Location	Equipt. Driven	Engine Builder	No. Engines	Horsepower	Speed, rpm	No. Cyl	Cyl Bore	Cyl Stroke	Horizontal or Vertical	Single or Tandem	Cycle	Btu per BHp-Hr	Type of Fuel	Btu per Cu Ft of Fuel
S'western Pub. Serv. Corp.	Carlsbad, N. M.	Gen.	R-J	1	1800*	240	8	23	28	V	S	4	9,500	Nat.	1000
Iowa Nebraska Lt. & Pwr.	Lincoln, Neb.	Gen.	Wor	2	1800	225	12	20	25	V	TW	4	.....	.....	....
Dakota Power Co.	Rapid City, S. D.	Gen.	Wor	3	1500	225	10	20	25	V	TW	4	.....	.....	....
Natural Gas Pipeline Co.	Harper, Iowa	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
	Perryton, Tex.	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
	Bloom, Kan.	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
Michigan Gas Trans. Corp.	Zionsville, Ind.	Comp.	Wor	4	1300	125	4	24	36	H	TT	4	.....	.....	....
	Montezuma, Ind.	Comp.	Wor	4	1300	125	4	24	36	H	TT	4	.....	.....	....
Panhandle Eastern Pipeline Co.	Pleasant Hill, Ill.	Comp.	Wor	3	1300	125	4	24	36	H	TT	4	.....	.....	....
		Gen.	Wor	2	180	514	6	9	10½	V	S	4	.....	.....	....
Panhandle Eastern Pipeline Co.	Centralia, Mo.	Comp.	Wor	2	1300	125	4	24	36	H	TT	4	.....	.....	....
		Gen.	Wor	3	180	514	6	9	10½	V	S	4	.....	.....	....
Panhandle Eastern Pipeline Co.	Olpe, Kan.	Comp.	Wor	3	1300	125	4	24	36	H	TT	4	.....	.....	....
		Gen.	Wor	4	180	514	6	9	10½	V	S	4	.....	.....	....
Panhandle Eastern Pipeline Co.	Tuscola, Ill.	Comp.	Wor	3	1300	125	4	24	36	H	TT	4	.....	.....	....
Southern Nat. Gas Co.	Louisville, Miss.	Comp.	Wor	2	1300	125	4	24	36	H	TT	4	.....	.....	....
	Perryville, La.	Comp.	Wor	3	1300	125	4	24	36	H	TT	4	.....	.....	....
Southern Nat. Gas Co.	Guthrie, La.	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
	Onward, Miss.	Comp.	Wor	4	1300	125	4	24	36	H	TT	4	.....	.....	....
	Reform, Ala.	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
Northern Natural Gas Co.	Bushton, Kan.	Comp.	Wor	3	1300	125	4	24	36	H	TT	4	.....	.....	....
	Bushton, Kan.	Comp.	Wor	2	900	150	4	20	30	H	TT	4	.....	.....	...
	Beatrice, Neb.	Comp.	Wor	1	1300	125	4	24	36	H	TT	4	.....	.....	....
Miss. River Fuel Corp.	Perrysville, La.	Comp.	NTP	2	1200	125	4	23	36	H	TT	4	9,500	Nat.	1000
Brady	Texas	Gen.	Wor	1	1000	225	8	18	25	H	S	4	.....	.....	....
Phillips Petroleum Co.	Borger, Tex.	Pump	Wor	2	650	125	2	24	36	H	ST	4	.....	.....	....
Natural Gasoline Corp.	Hobbs, New Mex.	Gen.	Wor	1	540	327	6	15	17½	V	S	4	.....	.....	....
Clarksburg Water Works	Clarksburg, W. Va.	Pump	Ster	1	500	....	8	8	9	V	S	4	10,000	Nat.	1000
				1	100	1200	6	5¼	6	V	S	4	10,000	Nat.	1000
Pure Oil Co.	Nederland, Tex.	Pump	Wor	3	500	180	2	20	30	H	ST	4	.....	.....	....
Tucumcari Light & Pwr.	Tucumcari, New Mex.	Gen.	Wor	1	495	327	6	15	17½	V	S	4	.....	.....	....
Harlingen Cot. Oil Mill	Harlingen, Tex.	Mill	BM	1	450	240	4	18½	20	V	S	4	10,000	Nat.	1000
Wichita Water Co.	Wichita, Kan.	Pump	Wor	1	450	327	5	15	17½	V	S	4	.....	.....	....
				1	300	400	5	12¼	14½	V	S	4	.....	.....	....
Phillips Pipe Line Co.	Cheney, Kan.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	But.	....
	Sharpe, Kan.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
Phillips Pipe Line Co.	Buffalo, Okla.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	But.	....
	Medicine Lodge, Okla.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	Nat.	1000
Phillips Pipe Line Co.	Madison, Kans.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
	Eldorado, Kan.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
Standish Pipe Line Co.	Sharpe, Kan.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
Phillips Pipe Line Co.	Sutherland, Mo.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
	Rosebud, Mo.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	But.	....
Phillips Pipe Line Co.	Villa Ridge, Mo.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	But.	....
	Syracuse, Mo.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	But.	....
Phillips Pipe Line Co.	Attica, Kan.	Pump	Ster	1	400	900	8	8	9	V	S	4	10,000	But.	....
	Nowata, Okla.	Gen.	Ster	1	400	900	8	8	9	V	S	4	10,000	Nat.	1000
Phillips Pipe Line Co.	Darrozett, Tex.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	Nat.	1000
	Stinnet, Tex.	Pump	Ster	2	400	900	8	8	9	V	S	4	10,000	But.	....
375–115 hp per Engine															
J. G. Boswell Co.	Corcoran, Calif.	Gen.	Ent	1	375	400	6	12	15	V	S	4	10,000	Nat.	1000
Western Supply	Wickett, Tex.	Gen.	Wor	3	360	400	6	12¼	14½	V	S	4	.....	.....	....
Corpus Christi Ref. Corp.	Corpus Christi, Tex.	Gen.	Wor	2	300	400	5	12¼	14½	V	S	4	.....	.....	....
		Pump	Wor	1	240	400	4	12¼	14½	V	S	4	.....	.....	....
Talco Asphalt & Ref. Co.	Mt. Pleasant, Tex.	Gen.	Wor	2	300	400	5	12¼	14½	V	S	4	.....	.....	....
				1	150	514	5	9	10½	V	S	4	.....	.....	....
Plains G. & H. Handling Co.	Slaton, Tex.	Shaft	BM	1	275	277	4	14½	17	V	S	4	10,000	Nat.	1000
Kettleman N. Dome Assn.	Huron, Calif.	Pump	BM	1	250	257	4	14½	17	V	S	4	10,000	Nat.	1000
Champlin Ref. Co.	Enid, Okla.	Pump	Wor	1	240	400	4	12¼	14½	V	S	4	.....	.....	....
Briercliff Gardens	Atlanta, Ga.	Gen.	Wor	1	240	400	4	12¼	14½	V	S	4	.....	.....	....
Skelly Oil Co.	Burrton, Kan.	Pump	Wor	2	240	400	4	12¼	14½	V	S	4	.....	.....	....
Roots-Connersville Blower Corp.	Lansing, Mich.	Blower	Wor	1	240	400	4	12¼	14½	V	S	4	.....	.....	....
Dr. C. D. Martin	Fletcher, Okla.	Gen.	FIW	1	225	277	3	15	18	V	S	4	.....	.....	....
San Dimas Water Co.	La Verne, Calif.	Pump	Ent	1	225	520	6	9½	11½	V	S	4	10,000	Nat.	1000
Brownfield	Texas	Alt.	BM	1	215	300	4	13½	15	V	S	4	10,000	Nat.	1000
National Transit Co.	Eldred, Pa.	Pump	NTP	1	200	210	2	17	24	H	TW	4	9,500	Nat.	1000
Sunray Oil Co.	Allen, Okla.	Gen.	Wor	1	180	514	6	9	10½	V	S	4	.....	.....	....
Coastal Refineries	Port Isabel, Tex.	Gen.	Wor	1	180	514	6	9	10½	V	S	4	.....	.....	....
Roots-Connersville Blower Corp.	Topeka, Kan.	Blower	Wor	2	180	400	3	12¼	14½	V	S	4	.....	.....	....
Southern Nat. Gas Co.	Louisville, Miss.	Alt.	BM	1	180	300	4	12¼	15	V	S	4	10,000	Nat.	1000
	Onward, Miss.	Alt.	BM	1	180	300	4	12¼	15	V	S	4	10,000	Nat.	1000
Graben Light & Power Co.	Ada, Okla.	Gen.	Wor	1	180	514	6	9	10½	V	S	4	.....	.....	....
Michigan Gas Trans. Corp.	Zionsville, Ind.	Gen.	Wor	2	180	514	6	9	10½	V	S	4	.....	.....	....
Midwest Dairies, Inc.	El Paso, Tex.	Alt.	BM	1	165	277	4	13½	15	V	S	4	10,000	Nat.	1000
		Alt.	BM	2	90	300	2	13½	15	V	S	4	10,000	Nat.	1000
Standard Oil Co. of Ohio	Lima, Ohio	Comp.	NTP	1	160	180	2	17	24	H	TW	4	9,500	Ref.	1600
	Cleveland, Ohio	Comp.	NTP	1	160	180	2	17	24	H	TW	4	9,500	Ref.	1600
Cortaro Farms Co.	Marana, Ariz.	Pump	Ent	4	160	640	6	8	10	V	S	4	10,000	Nat.	1000
Northern Natural Gas	Oakland, Iowa	Gen.	Wor	2	150	514	5	9	10½	V	S	4	.....	.....	....
	Mason City, Iowa	Gen.	Wor	2	150	514	5	9	10½	V	S	4	.....	.....	....
Natural Gas Corp.	Galva, Kan.	Gen.	Wor	3	150	514	5	9	10½	V	S	4	.....	.....	....
Southern Ice, Inc.	Little Rock, Ark.	Comp.	BM	1	145	360	4	11	12	V	S	4	10,000	Nat.	1000
		Alt.	BM	1	130	327	4	11	12	V	S	4	10,000	Nat.	1000
Louisville Brick Co.	Louisville, Miss.	Shaft	BM	1	145	360	4	11	12	V	S	4	10,000	Nat.	1000
		Alt.	BM	1	45	450	2	8½	9	V	S	4	10,000	Nat.	1000
Lincoln Ice Co.	Shreveport, La.	Comp., Alt.	BM	1	130	327	4	11	12	V	S	4	10,000	Nat.	1000
Polar Wave Ice Co.	Houston, Tex.	Alt.	BM	2	130	327	4	11	12	V	S	4	10,000	Nat.	1000
Bishop Oil Co.	Fittstown, Okla.	Gen.	NTP	1	125	720	8	6	9	V	S	4	10,000	Nat.	1000
Okla. Pipe Line Co.	Ada, Okla.	Pump	NTP	1	125	720	8	6	9	V	S	4	10,000	Nat.	1000
Jacob Basten	Sheboygan, Mich.	Pump	Wor	2	120	514	4	9	10½	V	S	4	.....	Sew.	650
Green Bay Met. Sewage	Green Bay, Wis.	Gen.	Wor	1	120	514	4	9	10½	V	S	4	.....	Sew.	650
				1	90	514	3	9	10½	V	S	4	.....	Sew.	650
Boston Consol. Gas.	Boston, Mass.	Comp.	Wor	1	120	514	4	9	10½	V	S	4	.....	.....	....
J. W. Bleidt Ice Co.	Little Rock, Ark.	Gen., Comp.	Wor	1	120	514	4	9	10½	V	S	4	.....	.....	....
Frigid Ice Co.	Atlanta, Ga.	Comp.	BM	2	120	300	4	11	12	V	S	4	10,000	Nat.	1000
		Alt.	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
New Ice Service Co.	Shreveport, La.	Comp., Alt.	BM	1	115	514	4	8¾	10½	V	S	4	10,000	Nat.	1000

ABBREVIATIONS—Alt.—Alternator, BM—Bruce-MacBeth Engine Co, But—Butane, Clk—Clark Bros. Co, Comp.—compressor, Ent—Enterprise Engine Co, FIW—Fulton Iron Works, Gen.—Generator, Nat.—Natural gas, NTP—National Transit Pump & Machine Co, Ref.—Refinery gas, R-J—Rathbun-Jones (associated with Ingersoll-Rand), S—single, Sew.—Sewage gas, ST—Single tandem, Ster.—Sterling Engine Co, TT—Twin tandem, Tw—Twin, Wauk—Waukesha Motor Co, Wor—Worthington Pump & Machy Co.

* 2200 hp at sea level.

Typical Gas Engines Under 110 Hp

Owner	Location	Equipt. Driven	Engine Builder	No. Engines	Horsepower	Speed, rpm	No. Cyl	Cyl Bore	Cyl Stroke	Horizontal or Vertical	Single or Tandem	Cycle	Btu per BHp-Hr	Type of Fuel	Btu per Cu Ft of Fuel
Northern Texas Utilities	Shamrock, Tex.	Alt.	BM	2	110	327	4	10	12	V	S	4	10,000	Nat.	1000
East Side Ice Co	Okla. City, Okla.	Comp.	BM	1	110	327	4	10	12	V	S	4	10,000	Nat.	1000
Long Bch. Fl. Control	Long Beach, Cal.	Pump	Wor	2	105	800	6	6½	7½	V	S	4	.....	.....	....
Sth. Mountain Water Co	Yucaipa, Cal.	Pump	Wor	1	105	800	6	6½	7½	V	S	4	.....	.....	....
Pure Ice Co	Culver City, Cal.	Comp.	NTP	1	100	600	8	6	9	V	S	4	10,000	Nat.	1000
		Comp.	NTP	1	80	600	6	6	9	V	S	4	10,000	Nat.	1000
		Comp.	NTP	1	50	600	4	6	9	V	S	4	10,000	Nat	1000
National Petroleum Co	Pleasantville, Pa.	Gen.	NTP	1	100	600	8	6	9	V	S	4	10,000	Nat.	1000
Horlock Ice Industries	Houston, Tex.	Alt.	BM	1	100	300	2	13½	15	V	S	4	10,000	Nat.	1000
Laclede Gas Light Co	St. Louis, Mo.	Comp.	NTP	1	100	720	8	6	9	V	S	4	10,000	Nat.	1000
Texas Pipe Line Co	Olivier, La.	Pump	NTP	11	100	600	8	6	9	V	S	4	10,000	Nat.	1000
Sunny Mount Orange Co	Riverside, Cal.	.....	Wor	1	90	720	6	6½	7½	V	S	4	.....	.....	....
Prairie Icing Co	Hoisington, Kan.	Comp.	BM	1	90	300	2	12¼	15	V	S	4	10,000	Nat.	1000
Grason Lt. & Pwr. Co	Okla. City, Okla.	Gen.	Wor	1	90	720	6	6½	7½	V	S	4	.....	.....	....
Magnolia Ice & Bottling Co	Texarkana, Ark.	Comp.	BM	1	90	300	2	12¼	15	V	S	4	10,000	Nat.	1000
		Comp., Alt.	BM	1	60	360	2	10	12	V	S	4	10,000	Nat.	1000
El Paso Nat. Gas Co	Acacia, Ark.	Gen.	Wor	4	90	514	3	9	10½	V	S	4	.....	.....	....
	El Paso, Tex.	Gen.	Wor	3	90	514	3	9	10½	V	S	4	.....	.....	....
	Jal, New Mex.	Gen.	Wor	1	90	514	3	9	10½	V	S	4	.....	.....	....
Thomaston Ice Co	Thomaston, Ga.	Comp.	Wor	1	90	514	3	9	10½	V	S	4	.....	.....	....
				1	45	720	3	6½	7½	V	S	4	.....	.....	....
Santa Monica Ice Co	S. Monica, Calif.	Comp., Gen.	Ent	2	90	550	4	8	10	V	S	4	10,000	Nat.	1000
				1	70	550	3	8	10	V	S	4	10,000	Nat.	1000
Wasco Cream & Const. Co	Bakersfield, Calif.	.....	Wor	2	90	720	6	6½	7½	V	S	4	.....	.....	....
				1	75	720	5	6½	7½	V	S	4	.....	.....	....
Dameral-Allison Co	Covina, Calif.	Comp., Gen.	Ent	2	90	550	4	8	10	V	S	4	10,000	Nat.	1000
Thomas Heating Co	La Crosse, Wis.	Gen.	Wor	2	90	720	6	6½	7½	V	S	4	.....	Sew.	650
Hutchinson	Kansas	Gen.	Wor	2	90	720	6	6½	7½	V	S	4	.....	Sew.	650
Liebmann Ice Co	Shawnee, Okla.	Comp., Alt.	BM	1	90	277	2	13½	15	V	S	4	10,000	Nat.	1000
Baker Ice Mchry. Co	Corpus Christi, Tex.	Comp.	Wor	1	90	720	6	6½	7½	V	S	4	.....	.....	....
Velsicol Corp	Marshall, Ill.	Comp.	NTP	2	80	600	6	6	9	V	S	4	10,000	Ref.	1500
Big Three Welding Equipt	Corpus Christi, Tex.	Comp.	BM	1	80	277	2	12¼	15	V	S	4	10,000	Nat.	1000
Coca Cola Bottling Co	Monroe, La.	Alt.	BM	1	80	277	2	12¼	15	V	S	4	10,000	Nat.	1000
Lake Oil Co	Ada, Okla.	Pump	NTP	1	80	600	6	6	9	V	S	4	10,000	Nat.	1000
Baker Ice Machy. Co	Corpus Christi, Tex.	Comp.	Wor	1	75	720	5	6½	7½	V	S	4	.....	.....	....
Alexandria Steam Laundry	Alexandria, La.	Gen.	BM	1	75	300	2	12¼	13	V	S	4	10,000	Nat.	1000
Memphis Nat. Gas Co	Lula, Miss.	Comp., Gen.	Wor	1	75	720	5	6½	7½	V	S	4	.....	.....	....
Del Rosa Water Co	S. Bernardino, Calif.	Pump	Ent	1	72	720	4	7	8½	V	S	4	10,000	Nat.	1000
Lilly Creamery Co	Bryan, Tex.	Comp., Alt.	BM	1	70	360	2	11	12	V	S	4	10,000	Nat.	1000
Ark.-La. Gas Co	Daingerfield, Tex.	Alt.	BM	2	70	360	2	11	12	V	S	4	10,000	Nat.	1000
Paramount Ice Co	Downey, Calif.	Comp.	Ent	1	70	550	4	7	8½	V	S	4	10,000	Nat.	1000
Consolidated Chemical	Bryant, Tex.	.....	Wor	1	70	800	4	6½	7½	V	S	4	.....	.....	....
General Petroleum Corp	Ventura, Calif.	Pump	Ent	1	70	550	4	7	8½	V	S	4	10,000	Nat.	1000
	San Pedro, Calif.	Pump	Wor	1	70	800	4	6½	7½	V	S	4	.....	.....	....
General Petroleum Corp	Wilmington, Cal.	Pump	Ent	1	70	600	4	7	8½	V	S	4	10,000	Nat.	1000
				1	35	850	4	4¾	6	V	S	4	10,000	Nat.	1000
Mitchell Ice & Storage	Louisville, Miss.	Comp., Alt.	BM	2	70	360	2	11	12	V	S	4	10,000	Nat.	1000
		Comp.	BM	1	45	450	2	8½	9	V	S	4	10,000	Nat.	1000
Claiborne Ice & CS Co	Homer, La.	Alt., Comp.	ABM	1	70	360	2	11	12	V	S	4	10,000	Nat.	1000
			BM	1	35	360	2	8½	9	V	S	4	10,000	Nat.	1000
Under 65 hp. per Engine															
J. R. Duncan	Holdenville, Okla.	Comp. Alt.	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
Bellevue Water Works	Bellevue, Ohio	Pump	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
D. M. & F. M. Jones	Corpus Christi, Tex.	Comp., Alt.	BM	3	65	327	2	11	12	V	S	4	10,000	Nat.	1000
Horlock-La P. Ice Industries	La Porte, Tex.	Comp., Alt.	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
Hollow Hill Dairy	Colton, Calif.	Pump	Ent	1	65	550	4	6½	8½	V	S	4	10,000	Nat.	1000
Crescent Ice Co	Ardmore, Okla.	Comp., Alt.	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
Minneapolis Gas Light Co	Minneapolis, Minn.	Comp.	Wauk	1	65	1200	6	4⅝	5⅛	V	S	4	11,500	.....	....
Crescent Ice Co	Vernon, Tex.	Comp., Alt.	BM	1	65	327	2	11	12	V	S	4	10,000	Nat.	1000
West Covina Water Co	Covina, Calif.	Pump	Ent	1	65	550	4	7	8½	V	S	4	10,000	Nat	1000
Maechtlin	San Dimas, Calif.	Pump	Ent	1	65	550	4	6½	8½	V	S	4	10,000	Nat	1000
Riverton	Wyoming	Pump	Wauk	1	65	1200	6	4⅝	5⅛	V	S	4	11,500	.....	....
East End Water Co	Pomona, Calif.	Pump	Ent	1	65	550	4	6½	8½	V	S	4	10,000	Nat	1000
Independent Ice Co	Durant, Okla.	Comp., Alt	BM	1	65	327	2	11	12	V	S	4	10,000	Nat	1000
Clinton Ice Co	Clinton, Okla.	Comp.	Wor	1	60	720	4	6½	7½	V	S	4	.....	.....	....
Fruitvale Met. Water Co	Fruitvale, Calif.	Pump	Wor	1	60	720	4	6½	7½	V	S	4	.....	.....	....
Wingert & Hunt	Anaheim, Calif.	Pump	Ent	1	60	500	4	6½	8½	V	S	4	10,000	Nat	1000
Macon Gas Co	Macon, Ga.	Alt.	BM	1	55	327	2	10	12	V	S	4	10,000	Nat	1000
Manaham Oil Co	Wewoka, Okla.	Pump	NTP	6	55	600	4	6	9	V	S	4	10,000	Nat.	1000
Athletic M & S Co	Ft. Smith, Ark.	Blower	NTP	1	50	720	3	6	9	V	S	4	10,000	Nat.	1000
Lone Star Gas Co	Dallas, Tex.	Gen.	NTP	3	50	600	4	6	9	V	S	4	10,000	Nat.	1000
United Gas System	Myrtis, La.	Comp.	NTP	18	50	600	4	6	9	V	S	4	10,000	Nat.	1000
Newport Beach	California	Pump	Ent	1	45	450	4	7	8½	V	S	4	10,000	Nat.	1000
Kokomo	Indiana	Gen.	Wor	1	45	720	3	6½	7½	V	S	4	.....	.....	....
Betbeze Bros	Meridian, Miss.	Comp.	BM	1	45	360	2	9	11	V	S	4	10,000	Nat.	1000
Meadville	Pennsylvania	Blower	Wor	1	45	720	3	6½	7½	V	S	4	.....	.....	....
Sunray Oil Co	Okla. City, Okla.	Pump	NTP	17	40	600	3	6	9	V	S	4	10,000	Nat.	1000
Cassel Water Co	Covina, Calif.	Pump	Ent	2	40	800	4	4¾	6	V	S	4	10,000	Nat.	1000
Ward Ice Co	Ft. Smith, Ark.	Comp.	NTP	1	40	600	3	6	9	V	S	4	10,000	Nat.	1000
United Gas Co	Shreveport, La.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Peoples Gas Co	Chicago, Ill.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Cedar Rapids Gas Co	Cedar Rapids, Iowa	Gen., Comp.	Wauk	2	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
E. K. Smith Fun'l Home	Pittsburgh, Kan.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Wisteria Gardens	Atlanta, Ga.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Ewing Bros	Atlanta, Ga.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Houston Oil Field Mat'l Co	Houston, Tex.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Manhattan Cafe	Victoria, Tex.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
White Pearl Laundry Co	Casper, Wyo.	Shaft	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Showboat Dance Hall	St. Louis, Mo.	Comp.	Wauk	1	35	1200	6	3¾	4¼	V	S	4	11,500	.....	....
Kewanee Sewage Dis. Pl	Kewanee, Ill.	Gen.	Wor	1	30	720	2	6½	7½	V	S	4	.....	Sew.	650
Dixon Sewage Dis. Pl	Dixon, Ill.	Gen.	Wor	1	30	720	2	6½	7½	V	S	4	.....	Sew.	650
Magnolia Pet. Co	Rotan, Tex.	Pump	NTP	1	30	600	2	6	9	V	S	4	10,000	Nat.	1000
Economy Plumb. & Heat	Elmhurst, Ill.	Gen.	Wor	1	30	720	2	6½	7½	V	S	4	.....	Sew.	650
Majestic Cafe	Shreveport, La.	Comp.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....
John Hamman, Jr	Houston, Tex.	Comp.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....
Kansas City Gas Co	Kansas City, Mo.	Gen., Comp.	Wauk	2	18	1200	4	3¼	4	V	S	4	11,500	.....	....
Riggs Market	Pittsburgh, Kan.	Comp.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....
Regehr Packing Co	Hutchinson, Kan.	Comp.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....
Beloit Creamery	Beloit, Kan.	Comp.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....
Atlanta Gas Co	Atlanta, Ga.	Gen.	Wauk	1	18	1200	4	3¼	4	V	S	4	11,500	.....	....

ABBREVIATIONS—Alt.—Alternator, BM--Bruce-MacBeth Engine Co, But.—Butane, Clk—Clark Bros. Co, Comp.—Compressor, Ent—Enterprise Engine Co, FIW—Fulton Iron Works, Gen.—Generator, Nat.—Natural gas, NTP—National Transit Pump & Machine Co, Ref.—Refinery gas, R-J—Rathbun-Jones (associated with Ingersoll-Rand), S—single, Sew.—Sewage gas, ST—Single tandem, Ster.—Sterling Engine Co, TT—Twin tandem, Tw—Twin, Wauk—Waukesha Motor Co, Wor—Worthington Pump & Machy Co.

Handy Facts

Here, in one place, are facts about oil and gas power, the kind of information you're always looking for in reference books

Prepared by L N ROWLEY, *Assistant Editor*

Oil & Gas Power

Gaseous Fuels

GASEOUS FUELS are clean, easy to handle, and, in many parts of the country, cheap. Local conditions such as availability and price usually determine the gas used.

Remember that heating value is an index of the worth of a gas, but that the size of engine cylinder for a given output depends on how much air must be mixed with the fuel for combustion. A good rule of thumb is: for every 100 Btu of lower heat value, about 1 cu ft of air is needed. Engine ratings depend on the heating value of the explosive mixture, which is roughly the same for all gases, except blast-furnace and producer.

Liquid Fuels

VIRTUALLY all liquid fuels derive from petroleum; the products include gasoline, kerosene, and fuel oil, in order of specific gravity. Important use of gasoline in the stationary field is for emergency and standby units. Kerosene, less volatile, is not as satisfactory a fuel for internal combustion engines, and finds little present use.

The bulk of internal-combustion output is generated from "fuel oils", a name that covers a wide range of products. Crudes of low commercial value, residuals from refinery operations, distillates, or blends of these, all come under this heading. Continuous effort to standardize grades has brought little result. Most engine makers specify the best oil for their engines; most users try to buy the cheapest oil these specs will permit.

Most important characteristics are ignition quality, cleanliness, and viscosity. Normally, maintenance costs go up when cheaper grades are burned; some outstanding cases show that this need not be true. Heavy oils, if a trial indicates they can be burned successfully, may offer real bargains, since the heat content per gal. increases with specific gravity.

Gas-Engine Types

PRACTICALLY all gas engines work on the Otto cycle, with spark ignition. In 4-cycle engines, the fuel-air ratio is maintained by a mixing valve and the quantity of mixture varied for governing. This can't be done with 2-cycle units since less than a full charge means imperfect scavenging. Only gas supply is regulated; rich or lean mixtures result at light and heavy loads. Advantages claimed for the 4-cycle type are lower fuel consumption, better regulation, and higher speed. Cheapness and ease of maintenance are the features of 2-cycle machines; improved fuel consumption due to injection of gas under slight pressure brings performance close to the 4-cycle. Most large engines are 4-cycle, as are most high-speed units.

Gas engines will burn almost any fuel efficiently, only changes required are in the mixing valve and in compression pressure.

TABLE II

Compression Pressures

Blast-furnace gas ...	150-200 lb per sq in.
Butane	75-200
Casinghead gas	70-90
Carbureted water gas	130
Coke-oven gas	80-100
Natural gas	100-115
Producer gas	100-165
Propane	125-350
Refinery gas	70-90
Sewage gas	110-180

TABLE I—GASEOUS FUELS

Fuel	*Source*	*Avg. Composition*	*High Heat Value-Btu/cu ft*	*Avg. Air for Comb. cu ft/cu ft*	*High Heat Value of Mixture-Btu/cu ft*	*Remarks*
Blast-furnace gas.....	Byproduct of iron-making	58% N_2, 27% CO, 12% CO_2, 2% H_2, some CH_4	90–100	0.7	53–59	Good fuel when cleaned —mainly used at source
Butane.....	Byproduct of gasoline-making, also in casing-head gas	C_4H_{10} (usually has some butylene, C_4H_8 and propane, C_3H_8	3200–3260	31	100	Liquifies under slight pressure, sold as liquid
Casinghead gas.....	Oil wells.....	Varies, mostly butane and propane	1200–2000	11.5–19	96–100	Mostly used in oil fields, some piped
Carburetted water gas.	Manufactured from coal, enriched with oil vapor	35% H_2, 34% CO, 15% CH_4, 13% C_2H_4, 2% N_2, 1% CO_2	500–600	4.5–5.5	95–99	Good fuel, but usually high in cost. Part of most city gas
Coke-oven gas.....	Byproduct coke ovens..	48% H_2, 32% CH_4, 8% N_2, 6% CO, 3% C_2H_4, 2% CO_2, 1% O_2	500–600	4.5–5.5	90–95	Good fuel when cleaned —often used at source
Natural gas.....	Gas wells.....	Varies widely — mostly CH_4, C_2H_6, C_3H_8	950–2200	9–21	94–99	Ideal fuel — piped to consuming centers
Oil gas.....	Manufactured from petroleum	54% H_2, 27% CH_4, 10% CO, 3% N_2, 3% CO_2, 3% C_2H_4	500–550	4–5	96–98	Widely used on Pacific coast — often mixed with coke-oven gas
Producer gas.....	Manufactured from coal, coke, wood, etc.	59% N_2, 22% CO, 11% H_2, 6% CO_2, 2% CH_4	135–165	1–1.5	65–73	Requires cleaning
Propane.....	Byproduct of gasoline	C_3H_8.....	2500	24	100	Similar to butane
Refinery gas.....	Byproduct of petroleum processing	Varies — mostly butane and propane	1200–2000	11.5–19	96–100	Mainly used at refineries — some piped
Sewage gas.....	Sewage disposal plants.	65% CH_4, 30% CO_2, 2% H_2, 3% N_2, traces of O_2, CO, H_2S	600–700	7–8	70–90	Many disposal plants meet all power needs with this fuel

Note: Compositions vary widely, those given are representative only. The heating value, air required for combustion, and heating value of the mixture show the range that might be encountered in practice.

Oil-Engine Types

GASOLINE and kerosene are burned in engines operating on the Otto cycle, with spark ignition in most cases. Fuel is vaporized and mixed with air in a carburetor; compression pressures for gasoline range from about 80-180 lb per sq in.

Most important of the fuel-oil engines is the diesel. Only air is compressed in the cylinder; fuel is injected (with air or mechanically); ignition is by the heat of compression; compression pressure runs about 500 lb. A relatively new development is a compression-ignition engine that burns gas injected at high pressure. Combustion is stabilized by injecting a small quantity of "pilot oil."

A few oil engines operate on the Otto cycle, using a hot surface for ignition, and with compression pressures from 60-150 lb. More modern engines of this type have compression pressures ranging from 250-350 lb, and work on cycles between the Diesel and Otto. A widely useful oil engine type uses spark ignition, with a compression pressure of 125 lb. All the above engines burn fuel oil; each has its advantages.

Engine Performance

BECAUSE of wide variations in the calorific value of gaseous fuels, gas engine performance is rated in Btu per bhp per hr. Most 4-cycle engines have guaranteed fuel-economies of 10,000 Btu per bhp hr, with some of the larger engines rated at 9500. Small engines (50 hp or less) may run about 11,500 Btu per bhp hr. 2-cycle engines with fuel injection under pressure have economies approaching these, but without injection the figure falls off to about 13,000-14,000. Performance at part loads, is, of course, less economical than at or near full load; Btu per bhp hr required increases about 10-20% at $\frac{3}{4}$ load, about 30-50% at $\frac{1}{2}$ load, and about 80-100% at $\frac{1}{4}$ load.

Gas-engine performance is affected by temperature and altitude. With 60 F as 100%, capacity at 120 F is about 90%. Increases in altitude have the same effect; at 5000 ft, an engine must be derated about 16-18%, and about 30-34% at 10,000 ft.

Lubricating-oil consumption varies with the type of engine, the care in operation, and whether it is reclaimed. No comprehensive figures are available. It is probably safe to figure 2600 hp hr per gal., although this can be bettered in many plants.

Oil Engines — Fuel-consumption guarantees for diesel engines are usually based on the use of oil of 19,000 Btu per lb, higher heating value, and are expressed in fractions of a lb per net brake hp hr. Modern fuel consumption guarantees range from 0.38 lb per bhp hr, for large engines, to about 0.50 lb for very small engines, the average for most being in the neighborhood of 0.40 lb. Spark-ignition oil engines approach this performance with economies ranging from 0.48 to 0.56 lb per bhp hr. Diesel-engine fuel economies fall off at lower loads, but not as sharply as gas engine economies. Fuel consumption at $\frac{3}{4}$ load increases about 1-3%, $\frac{1}{2}$ load about 8-16%, and at $\frac{1}{4}$ load about 48-60%.

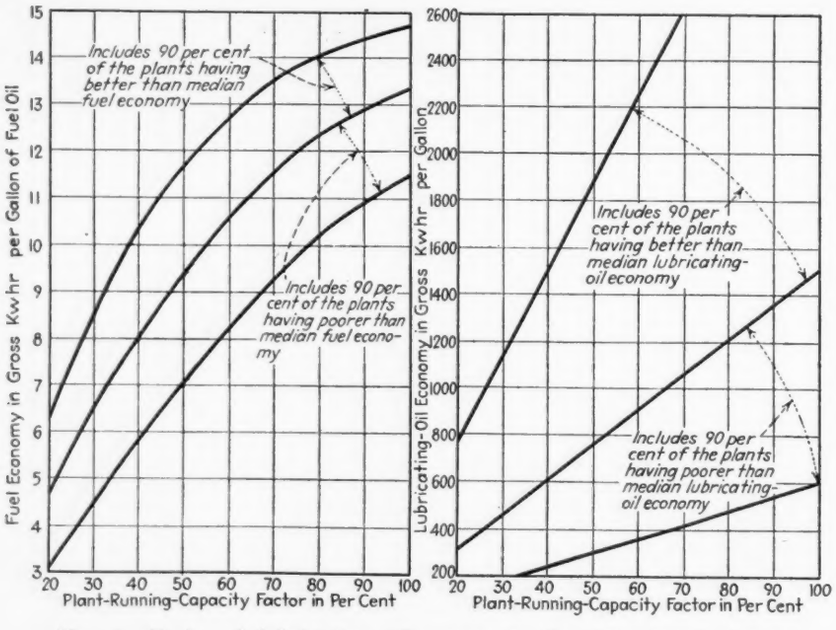

Fuel Economy in Gross Kwhr per Gallon of Fuel Oil
Includes 90 per cent of the plants having better than median fuel economy
Includes 90 per cent of the plants having poorer than median fuel economy
Plant-Running-Capacity Factor in Per Cent
Lubricating-Oil Economy in Gross Kwhr per Gallon
Includes 90 per cent of the plants having better than median lubricating-oil economy
Includes 90 per cent of the plants having poorer than median lubricating-oil economy
Plant-Running-Capacity Factor in Per Cent

Fig. 1—Fuel and lubricating oil economies for 119 diesel plants, surveyed in "Report on Oil-Engine Power Cost for 1936", by Oil and Gas Power Division, ASME

The Oil and Gas Power Division of the ASME has made extensive surveys of the performance of diesel plants, over a period of years. Fig. 1 presents a summary of some of the data gathered in the 1936 (most recent) survey. Plant running capacity factor is the gross output of the plant in kwhr divided by the total capacity in individual units, multiplied by the hours of operation of each unit. This factor is expressed as a percentage.

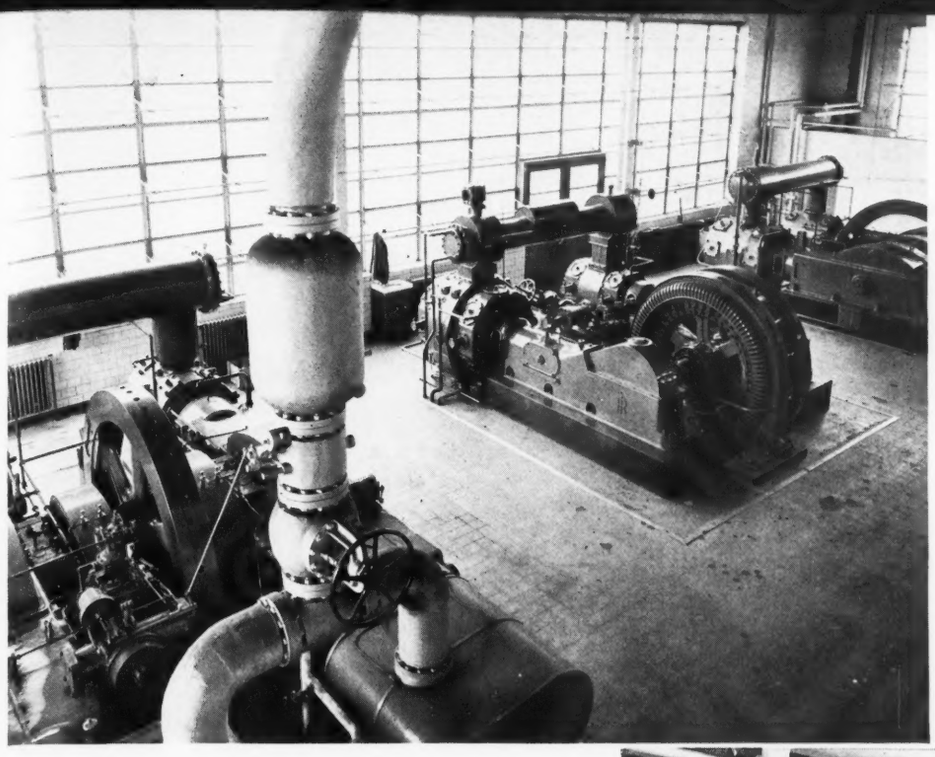
Costs

THE "Report on Oil-Engine Power Costs" (ASME), indicates that most plants generating between 1500 and 3000 kwhr per kw installed have total production costs of from 8-16 mills per net kwhr. These figures include attendance and maintenance, but no fixed charges.

First cost of diesel engines may range from $30-60 per hp, FOB factory, with standard minimum equipment only. Cost of complete diesel plants depend on the cooling system selected, land and building costs, storage facilities needed, and accessories. The range of costs is from about $100 to $200 per kw, with $150 a good working figure for the average plant.

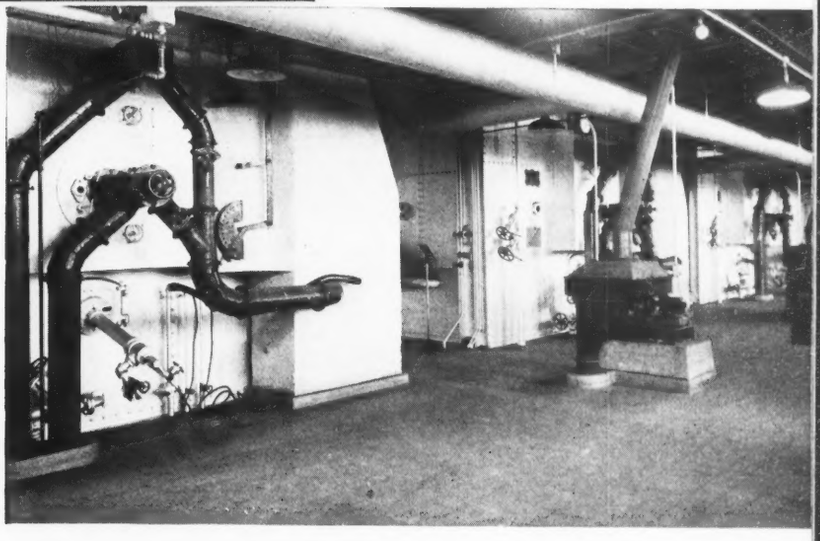
TABLE III
CONVERSION FACTORS FOR OIL AT 60 F

Gravity, Degrees API	Specific Gravity	Lb. per Gal.	Btu per Lb.	Btu per Gal.	Lb. per 42-Gal. Barrel
13	0.9792	8.16	18,690	152,510	342.88
14	0.9725	8.10	18,740	151,790	340.53
15	0.9659	8.05	18,790	151,260	338.22
16	0.9593	7.99	18,840	150,530	335.91
17	0.9529	7.94	18,890	149,980	333.64
18	0.9465	7.89	18,930	149,360	331.42
19	0.9402	7.83	18,980	148,610	329.23
20	0.9340	7.78	19,020	147,980	327.05
21	0.9279	7.73	19,060	147,330	324.91
22	0.9218	7.68	19,110	146,760	322.81
23	0.9159	7.63	19.150	146,110	320.71
24	0.9100	7.58	19.190	145,460	318.65
25	0.9042	7.53	19,230	144,800	316.59
26	0.8984	7.49	19,270	144,330	314.58
27	0.8927	7.44	19,310	143,670	312.60
28	0.8871	7.39	19,350	142,990	310.63
29	0.8816	7.35	19,380	142,440	308.70
30	0.8762	7.30	19,420	141,770	306.81
31	0.8708	7.26	19,450	141,210	304.92
32	0.8654	7.21	19,490	140,520	303.03
33	0.8602	7.17	19,520	139,960	301.18
34	0.8550	7.12	19,560	139,270	299.37
35	0.8498	7.08	19,590	138,690	297.57
36	0.8448	7.04	19,620	138,120	295.80
37	0.8398	7.00	19,650	137,550	294.04
38	0.8348	6.96	19,680	136,970	292.32
39	0.8299	6.92	19,720	136,460	290.64
40	0.8251	6.87	19,750	135,680	288.91
41	0.8203	6.83	19,780	135,090	287.23
42	0.8156	6.79	19,810	134,510	285.55



Air compressors: 2 Worthington steam-engine-driven, 1 Ingersoll-Rand motor-driven. Capacity of each is 3000 cfm

Boiler room: three 175-lb Union Iron Works boilers, each with 7530 sq ft heating surface and 65,000 lb per hr capacity



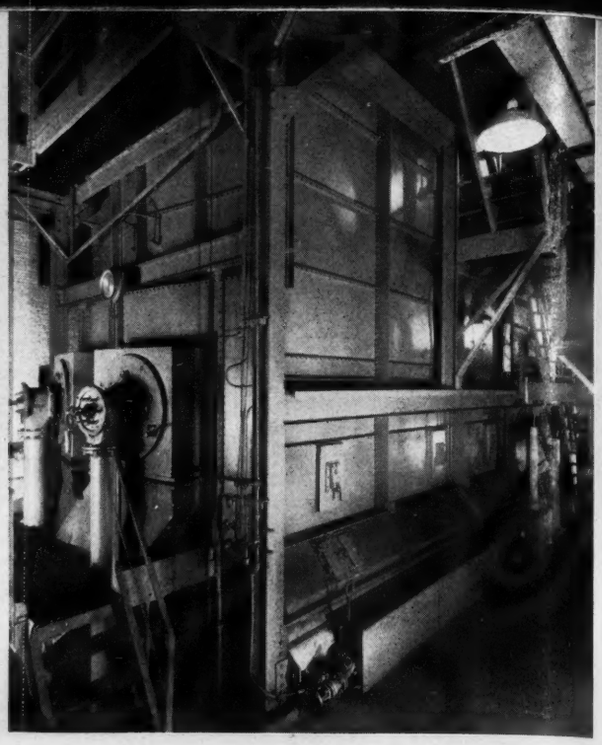
Power plant of Chevrolet's brand new Motor and Axle Plant—here 3500 men turn out 65 motor and axle assemblies per hour

Air for Axles

FURNISHING STEAM for air-compressor drive and for heating is the job of this pulverized-coal-fired boiler plant at Chevrolet's new 774,000-sq ft motor and axle plant at Tonawanda, N. Y. Two air compressors are steam driven, the other is motor driven for peak loads and standby. Auxiliary steam-generating equipment includes Smoot control apparatus, Richardson coal scales, Forney combination oil and gas burners, Kennedy-Van Saun coal burners, Clarage induced- and forced-draft fans, Worthington boiler-feed pumps, Elliott feedwater heaters, and Permutit hot-process softener with sand filters.

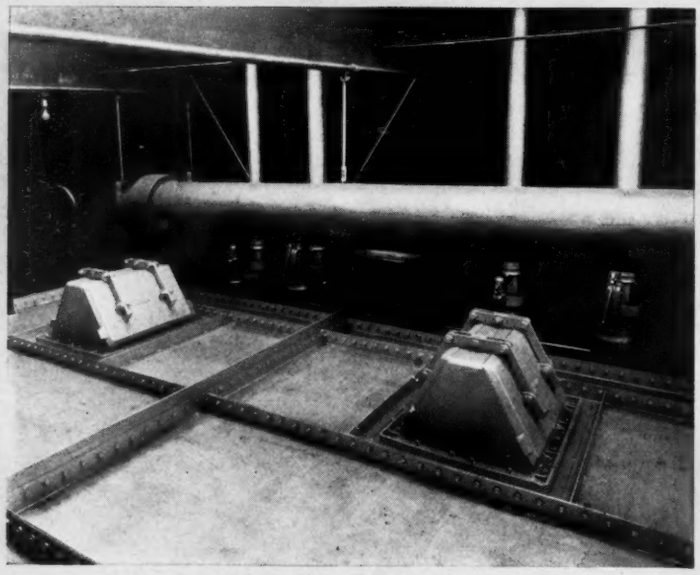
The Purchase of New Boiler Equipment is a Serious Matter to an Engineer

The responsibility of producing steam at the lowest possible cost and with dependable continuity of operation rests upon the shoulders of the power engineer. One of the most important functions of the engineer therefore is to recommend the installation of new modern boiler equipment when justified and to purchase the best possible equipment when new equipment is installed. His purchase definitely reflects his ability as an engineer. A thorough knowledge of present day design practice and operating characteristics is essential to intelligently select steam generating equipment.

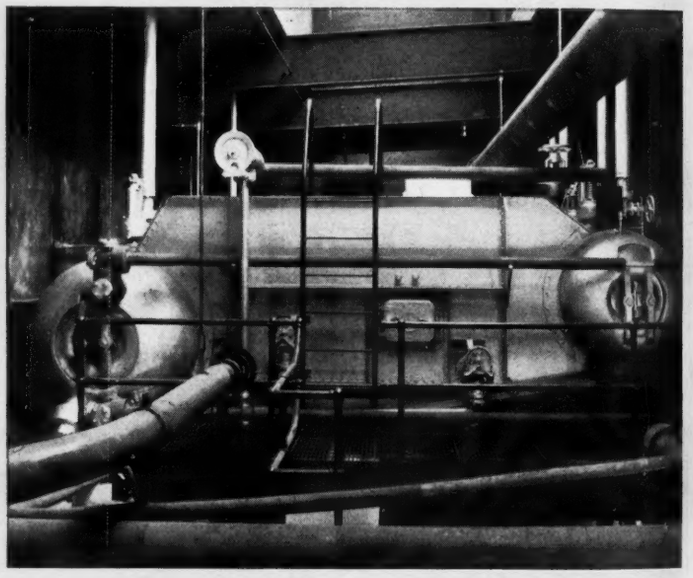


Firing Aisle
Bemis Bros. Bag Co.
Peoria, Ill.
Typical Riley Installation

A FEW PHOTOGRAPHS SHOWING WHAT YOU SEE



ROOF CONSTRUCTION



CONSTRUCTION UPPER SIDE WALLS

The SWING *to RILEY carried Riley Boiler Sales in the first quarter of 1938 higher than 1937 in spite of general downward business trend . . .*

TYPICAL

Northern Paper Mills, Green Bay, Wis.
Houston Power & Light Co., Houston, Texas
Allis Chalmers Mfg. Co., Milwaukee, Wis.
City of Columbus, Ohio
Boro of Lansdale, Pa.
Western Cartridge Co., E. Alton, Ill.
Winchester Repeating Arms, New Haven, Conn.
North Dakota Power & Light Co., Bismark, N. D.
Humble Oil & Refining Co., Baytown, Texas

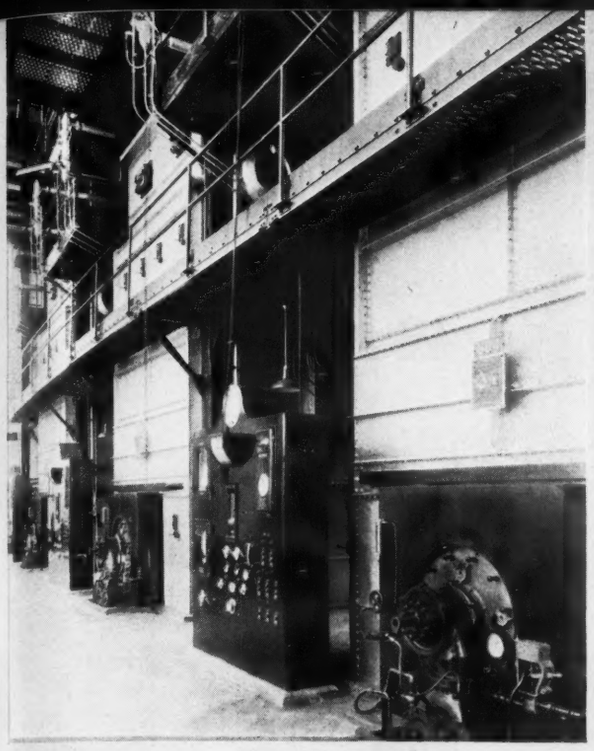
TRADE MARK Rx REGISTERED — CONTINUOUS PERFECTED CIRCULATION

RILEY

STOKER CORPORATION, WORCESTER, MASS.

Boston New York Philadelphia Pittsburgh Buffalo Cleveland Detroit Tacoma Baltimore Milwaukee Denver St. Louis Cincinnati Houston Chicago St. Paul Kansas City Los Angeles Atlanta Memphis New Orleans

It will pay you to visit modern Riley Installations

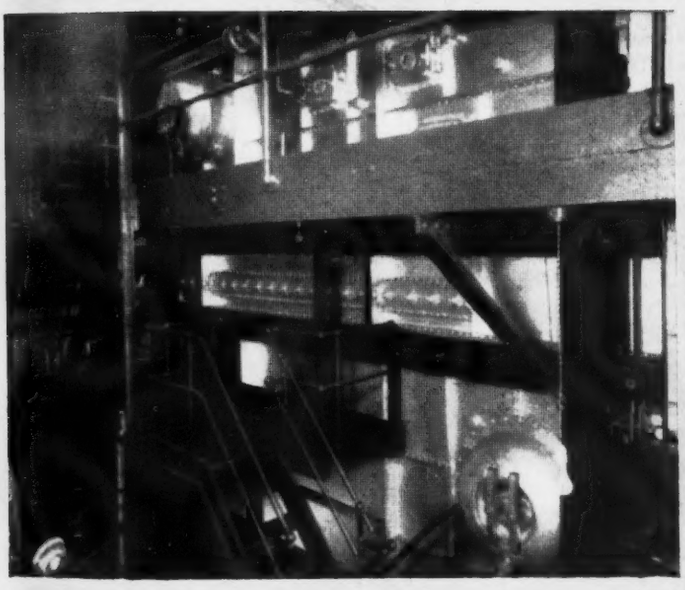


Firing Aisle
Forstmann Woolen Co.
Passaic, N. J.
Typical Riley Installation

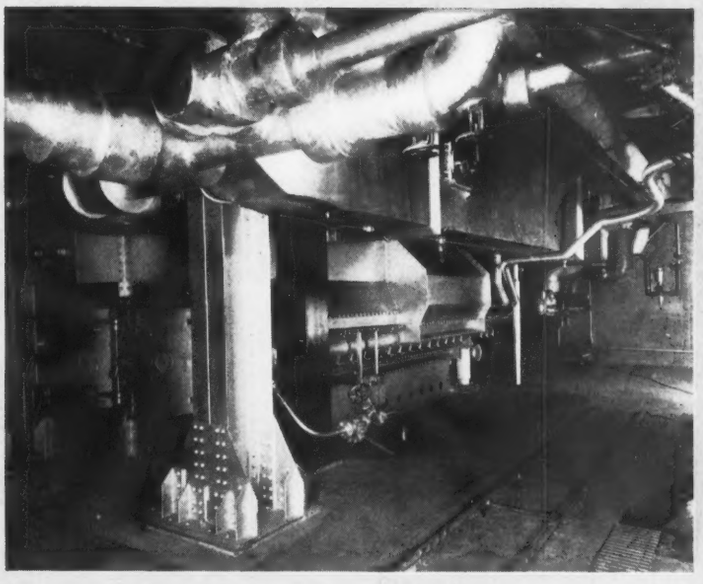
You have to get out in the Firing Aisle to properly select Boiler Equipment

You have to get out in the Firing Aisle to definitely find out about the comparative merits of boiler equipment. It simply can't be done at a desk by comparing competitive proposals. Isn't it only sensible to thoroughly investigate equipment actually performing in the field before making a purchase. Any manufacturer who is not afraid to subject his equipment to such an actual comparison of values encourages such investigations. Riley strongly recommends that you visit existing installations before purchasing equipment.

WHEN YOU VISIT MODERN RILEY INSTALLATIONS



SIDE WALL CONSTRUCTION



HOPPER BOTTOM CONSTRUCTION

RECENT RILEY INSTALLATIONS . . . .

Humble Oil & Refining Co., Ingleside, Texas
City of Detroit Lakes, Minn.
Great Lakes Steel Corp., Detroit, Mich.
Port Huron Sulphite & Paper Co., Port Huron, Mich.
Natrona Power & Light Co., Natrona, Pa.
Otter Tail Power Co., Wahpeton, N. D.
Hartford City Paper Co., Hartford City, Ind.
Celanese Corp. of America, Cumberland, Md.
Hellwig Silk Dyeing Co., Philadelphia, Pa.

Libby Owens Ford Glass Co., Rossford, Ohio
Central Ohio Power & Light Co., Bluffton, Ohio
General Aniline Works, Rensselaer, N. Y.
American Brass Co., Kenosha, Wis.
Godchaux Sugars, Reserve, La.
Moore Steam Turbine Co., Wellsville, N. Y.
Riverside Metal Corp., Riverside, N. J.
W. Va. Pulp & Paper Co., Luke, Md.
W. Va. Pulp & Paper Co., Covington, Va.

Newport Electric Co., Newport, R. I.
Publicker Commercial Alcohol Co., Philadelphia, Pa.
Burroughs Adding Machine Co., Detroit, Mich.
Wheeling Steel Corp., Portsmouth, Ohio
Central Illinois Light Co., Peoria, Ill.
MacAndrews & Forbes Co., Camden, N. J.
University of Maryland, College Park, Md.
North Dakota Power & Light Co., Beulah, N. D.
Fort Bend Utilities Co., Sugarland, Texas.

A survey of your power plant by a consulting engineer will possibly show ways of making surprisingly large savings in power costs

COMPLETE STEAM GENERATING UNITS

BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • AIR HEATERS
ECONOMIZERS • WATER-COOLED FURNACES • STEEL-CLAD INSULATED SETTINGS • FLUE GAS SCRUBBERS

before purchasing Boiler or Fuel Burning Equipment

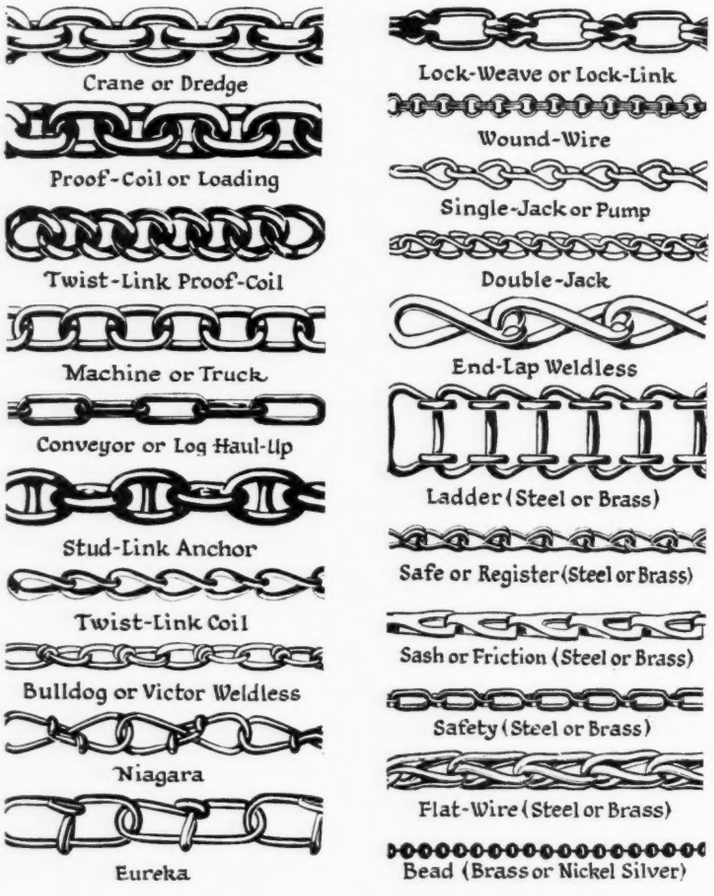
Number 70

Chains and Accessories

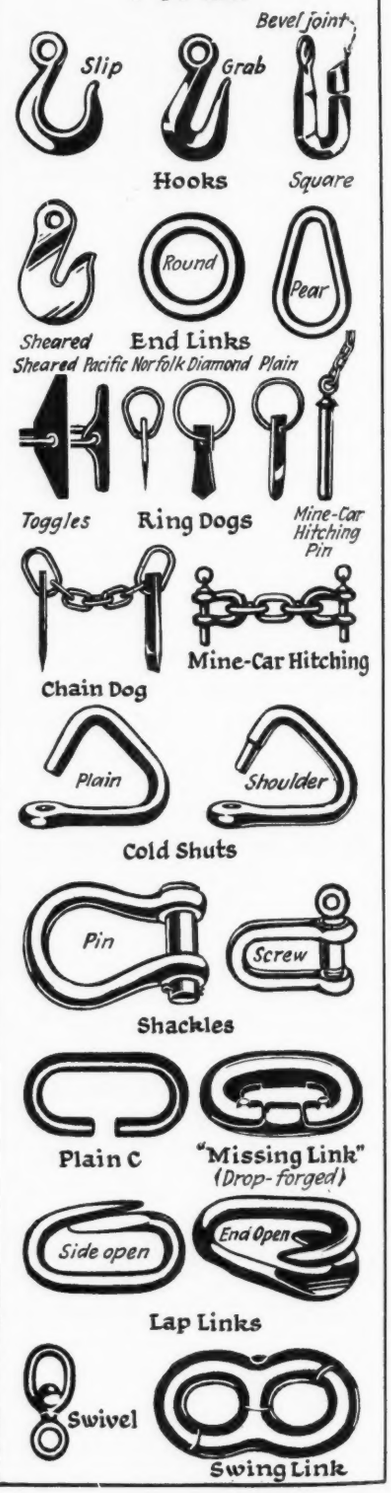
PROOF AND BREAK-TEST LOADS—A S T M

Nominal Size of Chain Bar, In.	PROOF TEST LOAD LB		BREAK TEST LOAD LB		SAFE WORKING LOAD LB		NOMINAL WEIGHT—PER 100 Ft, Lb	
	Crane Chain Wrought Iron	Proof Coil Iron or Steel	Crane Chain Wrought Iron	Proof Coil Iron or Steel	Crane Chain Wrought Iron	Proof Coil Iron or Steel	Crane Chain	Proof Coil
1/4	1 767	1 700	3 535	3 400	1 060	850	78	70
5/16	2 760	2 650	5 520	5 300	1 655	1 325	115	105
3/8	3 975	3 850	7 950	7 700	2 385	1 925	166	158
7/16	5 415	5 250	10 830	10 500	3 250	2 625	220	210
1/2	7 072	6 850	14 145	13 700	4 240	3 425	275	265
9/16	8 947	8 650	17 895	17 300	5 370	4 325	350	335
5/8	11 047	10 700	22 095	21 400	6 630	5 350	430	410
3/4	15 900	15 350	31 800	30 700	9 540	7 675	615	580
7/8	21 622	20 900	43 245	41 800	12 960	10 450	820	780
1	28 275	27 350	56 550	54 700	16 950	13 675	1045	1000
1 1/8	33 400	.....	66 800	.....	20 040	.....	1310	....
1 1/4	41 250	.....	82 500	.....	24 750	.....	1600	....
1 3/8	49 900	.....	99 800	.....	29 910	.....	1930	....
1 1/2	59 350	.....	118 700	.....	35 600	.....	2335	....
1 5/8	69 750	.....	139 500	.....	41 800	.....	2740	....
1 3/4	80 800	.....	161 600	.....	48 450	.....	3180	....
1 7/8	92 750	.....	185 500	.....	55 300	.....	3650	....
2	105 500	.....	211 100	.....	63 300	.....	4100	....

TYPES OF CHAIN



CHAIN ACCESSORY TYPES



© POWER

Current Comment

Causes of Black Spots on Commutators

Causes of black spots on commutators, mentioned in GCC's question in February *Power*, are sometimes hard to locate and remedy. Remember to clean all copper and stone dust from the machine after truing a commutator.

Some of the things that may happen to the machine while it is in service to cause black spots are: brushes shifted off neutral, brushes sticking in holders or worn too short, and insufficient pressure on brushes. The latter will also cause heating of the commutator and brushes. Maintain a pressure of 1.5 to 2 lb per sq in. on the brushes. Brushholders should be equally spaced and set about ⅛ in. from the commutator. Brushes that are too soft will blacken a commutator, particularly if current density is too high.

The commutator may have an eccentric motion, because of an out-of-round commutator, a sprung shaft or worn bearing. Defective armature or field-coil insulation, or poor connection between armature coils and commutator may create conditions that will cause black spots on the commutator.

Chicago, Ill. W W Bell

A Length of Pipe Or a Hammer Blow

In January *Power* there appeared an article describing a method of reinforcing sections of pipe used to afford additional leverage on wrench handles. While this strengthening will no doubt eliminate many of the safety hazards mentioned, the fact remains that pipes should not be used on wrench handles.

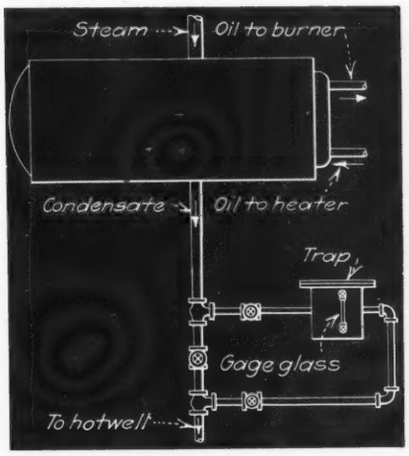
When excessive force is applied to a wrench handle, the man using the tool is always endangered. The handle may break, jaws may spread or the wrench may slip off the nut entirely. Even though the wrench stands the strain, there is danger of the bolt or stud shearing and causing the workman to fall.

When balky nuts must be loosened, it is far safer to use a short handled wrench arranged for striking with a hammer. The instantaneous force of the hammer blow has a tendency to break loose the corrosion or galled metal in the threads and thus avoid straining the metal beyond its elastic limit.

Roanoke, Va. S H Coleman

Keep Boilers Free from Fuel Oil

Oil on internal boiler surfaces is dangerous, as has been mentioned in *Power* frequently. The figure shows a typical fuel-oil-heater installation. Should an oil-heater tube split, internal surfaces of the boiler would become covered with



heavy deposits of fuel oil in a short time.

In some cases, oil-heater-trap discharge is piped to waste—the safest practice. Where a considerable amount of steam is used in heating fuel oil, and where pure condensate is at a premium, it may be desirable to save the condensate from the trap discharge. Under these conditions, place the trap so that it will be visible from the operating floor, and provide it with a gage glass as shown. This should be observed by the operator as often as the boiler gage glass, as oil leakage in the heater will soon show up on the glass. If leakage does occur, the boiler should be shut down immediately for cleaning and repair of the defective heater tube or coil.

Cleveland, O. A G Wiggins

Diesel Future

The editorial "Diesel Future," March *Power*, gives, I think, a very just and illuminating perspective of the diesel vs steam situation.

Your readers probably are not so much interested in marine power, but the situation there is also worth noting. Ships equipped with compound turbines and double-reduction gears, using steam at 400 lb and 750 F, and developing around 4000 shaft horsepower (as represented by a number of bulk-oil tankers recently put into service), now have the consumption of Bunker C oil down to about 0.55 to 0.6 lb per shaft horsepower hour. This includes oil for all purposes, that is, steam for the galley, heating, baths, etc.

The diesel people are able to do about 0.4 lb per shaft horsepower hour, and can ordinarily recover enough heat from the diesel exhaust to cover heat requirements. The high-speed diesels, however, which are just now receiving much attention in connection with geared drive of the new cargo ships proposed by the Maritime Commission, require, I believe, a comparatively good grade of oil, something like that used for house heating. This is the grade of oil that I assume the new General Motors diesels will require and that is referred to in your editorial as costing 6 cents per gallon in this country.

In the March 3, 1938, issue of *Oil & Gas Journal*, 20-30 diesel oil is quoted at $2.10 per barrel, to which there is to be added a lighterage charge of 6½ cents for delivery to ships in New York Harbor. Bunker C, which is burned under boilers, is quoted at $1.25, with a lighterage charge of 5 cents. In coastwise service, steam, therefore, has considerably the better of it, although when foreign voyages are considered, the cost of transportation must be added to the original cost of the oil, and here diesels compete on more favorable terms. However, as you have indicated, high-pressure steam has not yet reached its limits, and this is particularly true on shipboard, where the savings in space and weight which it makes possible are of great value.

New York, N. Y. Geo H Gibson

Escape Pipes for Safety Valves

The article "Escape Pipes for Safety Valves," February *Power*, is timely and explains conditions which call for correction. The diagram, however, does not show a drain in the safety-valve body, yet the ASME Boiler Code calls for such a drain. Many safety valves are constructed so that seats are below the level of the escape-pipe opening. Even though the safety-valve discharge or escape pipe may be drained at the lowest point, safety-valve body must also be properly drained.

If a discharge pipe is installed, moisture may form inside the discharge pipe and run down on top of the boiler shells. Means should be provided to take care of this condition.

Often, safety-valve-discharge pipes are supported from wooden trussed roofs and weight of snow on the roof throws a stress upon the safety-valve supports. If possible, safety-valve-discharge piping should be supported independently of the wooden-roof trusses.

Binghamton, N. Y. C W Carter, Jr

Cutout Prevents Reverse Polarity

Although the generator mentioned in question 2, December *Power*, is designated as shunt wound, many modern interpole machines have a small series-field winding. This might be sufficient to neutralize the shunt winding if the machine is operated considerably below its rated voltage and failure of power input has occurred.

To guard against this trouble, protect the generator with an automatic cutout similar in principle to those used

with automotive and railway-car lighting generators. The cutout can be arranged so that its shunt winding will cause it to close as soon as generator voltage is slightly above battery voltage. As soon as there is a reverse current from the battery, the series winding will neutralize the shunt winding and cause the cutout to open.

Altoona, Pa. A R MARKLAND

Eliminating Slagging

IT IS better to prevent the formation of slag than to try to cure it afterward. In my belief, slagging starts in the fuel bed; consequently, it is necessary to improve fuel-bed conditions if slagging is to be eliminated. My own experience has indicated that this theory is correct in practice. Specifically, slagging is due to non-uniform porosity of the fuel bed.

It is well known that, in any fuel bed, some parts burn more quickly than others. Slow burning results from a deficiency of air supply in parts where the fuel bed is less porous. This is particularly true with multiple-retort under-feed stokers where, on account of feeding of fuel by means of a ram, a compact fuel bed is obtained and parts of it, especially in the middle line of the retorts, do not receive sufficient air so that coal distills but does not burn entirely. Tarry products from this distillation are drawn through the boiler tube bank. As the tubes are at relatively low temperatures, the tarry products condense on them and form a slime on which flyash and unburned particles of fuel stick. Due to the effect of radiation, they harden and become vitrified, sticking to the tubes.

To prevent slagging, it is necessary to act on the fuel-bed itself, to maintain a good distribution of air and uniform porosity. Based on my experience, the use of several series of stepped secondary pushers in each retort, adjacent series working in opposite directions, is necessary to achieve this end.

To remove slag from tubes, French power plant men lance with water and with sand. These methods should not be used, and the troubles encountered confirm this opinion. When lancing with cold water, tubes which are at a relatively high temperature, in comparison to that of the water used, suddenly contract causing leaks and changes in the structure of the metal, rendering it brittle. Secondly, cold water acts chemically on the SO_2 contained in the combustion gas and transforms it into H_2SO_4, which attacks the steel of the economizer tubes. This action causes pitting of the tubes and leaks. Sanding of tubes is always dangerous; in fact, it must not be forgotten that sand is used to cut thick pieces of glass such as those used in portholes of ships. There is no doubt that even when very carefully practiced, sanding causes wear of tubes and weakens them rapidly. Consequently the remedy is worse than the evil.

Bièvres, France MAURICE RATEL

Diesel Shakes Windows

MR. ADAM'S "Today's Diesel Practice," in April *Power*, recalls a rather astonishing experience in the early days of my career when I was designing and supervising the installation of an 850-hp Fairbanks-Morse engine-generator. The engine was 2-cycle, with six cylinders, and a seventh scavenging-air-pump cylinder in line. It was placed parallel to, and about eight feet distant from, the end wall of the engine room. The air pump suction ran in a straight line from the cylinder to the wall. Passing through, it entered a concrete box, into the exposed face of which were set several sectional air filters.

About 40 ft. away, and directly in line with the engine room, was the city's water pumping station, a rather old, 2-story brick building. The factory-type windows, of early vintage, had wood instead of steel frames.

Came the day for "turning her over." After making a last check, I told the erector to go ahead. The engine started promptly and settled at once into a smooth cadence. For perhaps five minutes all was orderly and normal. Suddenly, the door of the engine room burst open and in came the water-plant operator, alarm written all over his face. "Your g—— d—— engine is shaking hell outa my water plant!", he exploded. I jumped to the control lever, shutting the engine down instantly; wondering as I did so if we had inadvertently put the concrete foundation near some tricky earth or rock strata that was carrying vibration to the water plant.

With the engine stopped, the water-plant operator regained sufficient composure to tell me "maybe the whole plant wasn't shaking—but anyhow the windows sure were." This sounded equally ridiculous, but upon subsequent trial we found it literally true. The large window in the water plant, 40 ft away and directly opposite the filters, set up a "bellows action" exactly in step with the suction strokes of the air pump. We later observed engine-room windows doing the same thing to a lesser degree.

In the end we enclosed the filters with an entering chamber, and brought air into it through a vertical stack extending above the roof. This all happened ten years ago, and to the best of my knowledge, the water-plant windows are still intact. In view of this experience, I couldn't help but wonder about the window behind the "Simple filter installation for 1000-hp De La Vergne," in Fig. 2 of Mr Adam's story.

Tecumseh, Kan. H M NAYLOR

Engineers' Bookshelf

Pumps

STANDARDS OF HYDRAULIC INSTITUTE (1937)—*Published by Hydraulic Institute, 90 West St, New York, N. Y. Paper cover, 180 pages, 9x12 in.; illustrated; tables and charts. Price $1.00.*

These standards are divided into seven sections: general, centrifugal pumps, rotary pumps, reciprocating pumps, deep well pumps, test codes, and data. This material is more than a standard code because it deals not only with data on which standards are formed, but also instructions for installation and operation.

For example, the section on centrifugal pumps has nine pages of definitions and descriptions of parts and different kinds of construction; three pages on standards of volume, head, power and efficiency guarantees; eleven pages on specific speed and suction lift, seven of which are suction-head charts; five pages of instructions for installing centrifugal pumps; two pages of operating instructions, about one half of which is devoted to pump troubles; and two pages on special pump applications.

The data section includes many valuable tables and charts necessary in applying pumps, including a 4-page table and chart of flow velocity and friction-head loss in pipes and fittings from ¼-in. to 48-in. in diameter; and a 5-page table listing pump-construction materials for handling various liquids.

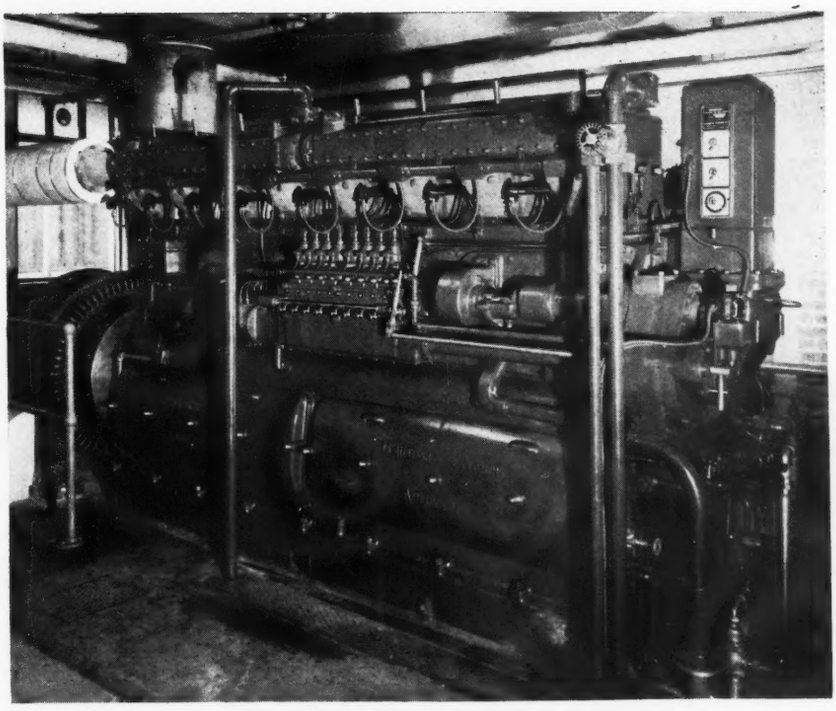
This material is submitted as being the opinion and recommendation of the Hydraulic Institute. Everyone interested in pumping problems will find that these Standards contain a wealth of practical information.

Electrical Code

NATIONAL ELECTRICAL CODE HANDBOOK (4th Edition, 1937)—*By Arthur L Abbott. Published by McGraw-Hill Publishing Co, Inc, 330 West 42nd St, New York, N. Y. Semi-flexible binding, 561 pages, 5x7 in., illustrated, 39 tables. Price $3.00.*

The National Electrical Code is recognized in most localities as the standard for light and power wiring and devices. This book, based on the 1937 Code, will enable the reader to grasp readily the general plan, scope and intent of these requirements. Grouping of the rules on the front inside cover according to a key, which in general permits placing all rules on one subject together, assists greatly in making the Code more readily understood.

(*Continued on page* 134)



STANDBY POWER

This 415-hp, 720-rpm, 8-cyl, 9½ x 10¼ McIntosh & Seymour diesel with Woodward governor and Korfund vibro-dampers is direct-connected to a 3-phase, 6-cycle, 208/120-volt, 285-kw GE generator—ready to go into action if power supply to the New York Telephone Co's office at 2nd Ave and E 13th St fails. A tank with a 2-day supply of oil is behind the brick wall in the rear

Power Lines

ASHVE Lists Program for Summer Meeting

The tentative program for the summer meeting of the American Society of Heating and Ventilating Engineers, to be held at The Homestead, Hot Springs, Va., June 20 to 22, lists ten technical papers and an extensive program of entertainment.

The Council of the society will hold its semi-annual meeting on June 19. A meeting of the society's Committee on Research, of which W L Fleisher of New York is chairman, will be held in connection with the technical sessions. The banquet and dance takes place on the evening of June 21.

Papers scheduled for presentation and discussion are:

"A Test Method for Air Cleaning", by R S Dill; "The Flow of Air Through Exhaust Grilles", by A M Greene, Jr and M H Dean; "The Condensation Nuclei Content of the Air as Related to Air Freshness", by R A Nielsen; "Heat Transfer Through Single and Double Glazing", by M L Carr, R A Miller, Leighton Orr and Alan C Byers; "Glass Heat Transfer Coefficients", by D Shore; "Performance of Surface Coil Dehumidifiers for Comfort Air Conditioning", by G L Tuve and L T Seigel.

"Seasonal Variations in Effective Temperature Requirements", by F E Giesecke, W H Badgett and F C Houghten; "Cooling Requirements for Summer Comfort Air Conditioning in Toronto", by C Tasker; "The General Reactions of 275 Workers to Summer Cooling and Air Conditioning", by A B Newton and F C Houghten; "Study of Summer Cooling in the Research Residence Using a Small Capacity Mechanical Condensing Unit", by A P Kratz, S Konzo, M K Fahnestock and E L Broderick.

Harold Sinclair Visits America

Harold Sinclair, managing director of Hydraulic Coupling and Engineering Co, Ltd, Isleworth, England, arrived in New York, May 2, on a business trip to this country. One of the chief objects of his trip is to exchange experience concerning general industrial, power-plant, railroad and other applications of the Vulcan-Sinclair fluid coupling with the Hydraulic Coupling Div, American Blower Corp.

Mr. Sinclair has been actively engaged since 1928 in the development of the fluid coupling from its original form in which it was produced for marine propulsion by Vulcan-Werk, Hamburg, Germany. While in this country last year, Mr. Sinclair was presented with the Edward Longstreth medal by the Franklin Institute for his work in adapting the Föttinger hydraulic coupling to variable-speed drives in industry and power plants.

On May 25, Mr. Sinclair gave a talk illustrated with lantern slides before the Metropolitan Section of the ASME on the application of variable-speed hydraulic couplings to power-plant auxiliaries. The talk was based on a comprehensive 75-page paper, "Some Problems in the Transmission of Power by Fluid Couplings", presented before the British Institution of Mechanical Engineers, April 22 of this year. This paper covers the developments in hydraulic couplings since October 1935, when Mr. Sinclair presented his paper, "Recent Developments in Hydraulic Couplings".

An article on hydraulic couplings by G V Edmonson, American Blower Corp, will appear in July *Power*.

Work Speeded on Flathead Hydro Station

Work on the giant $4,000,000 Flathead hydroelectric project of the Montana Power Co on the Flathead River, near Polson, is being speeded so that the station can go into operation this year. Frank M Kerr, president and general manager, stated that this project was the major item in the $5,300,000 construction program last year to give the people of Montana better electric service. In 1936 the company spent $2,101,000.

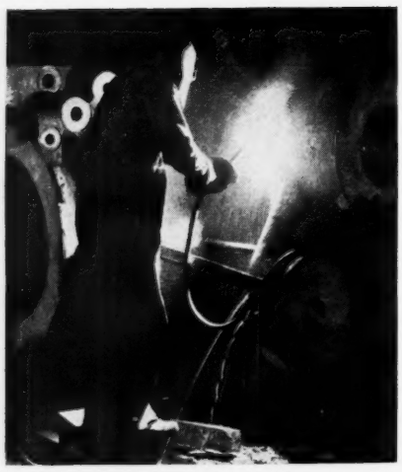
Scheduled for completion this year, the Flathead project will have, for the present, one generator with 56,000 kw capacity. Others are to be added as demand warrants. The diversion tunnel through which the waters had been detoured a year and a half, was closed on April 11 and within 36 hours the river rose 200 ft. The dam has created a reservoir of 1,100,000 acre-feet of water.

Annual Power Show Dec 5-10 in New York

The 13th National Exposition of Power and Mechanical Engineering will be held this year at Grand Central Palace, New York, N. Y., during the week of December 5 to 10. Since its inception in 1922, the Power Show has become the traditional means by which the industry's manufacturers and engineers convene to take inventory of power-equipment advances. Manufacturers in the power and allied fields will display their latest products; and professional engineers, public utility executives, dealers, and technical operatives will be on hand to inspect the latest machine and material developments, and to weigh comparative values.

At the last Exposition, in 1936, held at Grand Central Palace, visitors came from 1286 cities and towns in 42 states of the United States, and from 109 cities and towns in 35 foreign countries. The total registered attendance was 38,943.

(*Continued on page* 136)



TOP WELDING

Upper half of cylinder casing for a large 25-cycle topping steam turbine under construction in Allis-Chalmers shops. Electric welding eliminates complicated casting otherwise necessary

STRAWS

Pointing the way business winds blow

ALABAMA——Muscle Shoals Shoe Mfg Co, Muscle Shoals, plans boiler house at new shoe-manufacturing plant, 200x400 ft. Electric power supply will be secured from TVA and power substation will be built at factory for this purpose. Entire project will cost about $85,000.

Construction Service, Veterans' Administration, plans power house a new hospital group on Atlanta Highway, near Montgomery. Pumping station and other utilities will be installed. Cost about $1,000,000.

ARKANSAS——Paragould has received low bid from R H Bouligny, Inc, Charlotte, N. C., at $133,428, for extensions in waterworks building for installation of a municipal electric plant, including diesel-generator units and auxiliaries, switchboard, etc. W A Fuller & Co, 2916 Shenandoah Ave, St. Louis, Mo., consulting engineers.

CALIFORNIA——Board of County Supervisors, Los Angeles, plans central-heating plant in new Naval Reserve Armory on Chavez Ravine Blvd for which $1,000,000 has been arranged. Stiles O Clements, Van Nuys Bldg, Los Angeles, architect.

Alhambra City High School District, Alhambra, plans boiler house for central-heating service at new high school group in Eastern part of city. Cost about $800,000.

Ventura Citrus Assn, Ventura, plans air-conditioning system in new 1-story and basement addition to fruit-packing plant, 131x169 ft, for which work will begin soon. Cost about $85,000. W W Ache, 301 N Citrus Ave, Los Angeles, architect.

Montgomery Ward & Co, 2825 E 14th St, Oakland, plans air-conditioning plant in department store at Fresno.

Hancock Oil Co of California, Inc, 2828 Junipero Ave, Long Beach, plans pumping station, steel storage tanks, pipelines and other operating facilities at new bulk-oil terminal in St. Johns district, Portland, Ore. Cost over $100,000.

COLORADO——Bureau of Reclamation, Denver, contracted Pomona Pump Co, for pumping machinery and auxiliaries for pumping stations Nos. 1, 2, 3 and 4, Contra Costa Canal, Central Valley project, Cal., at $78,766.29.

"Pueblo Star-Journal," Pueblo, Frank S Hoag, president, plans air-conditioning system in 3-story newspaper printing and publishing plant, 120x120 ft.

CONNECTICUT——Eastern Color & Printing Co, 61 Leavenworth St, Waterbury, plans boiler plant for heating service in new 1-story printing and storage plant on

(*Continued on page* 126)

NEW PLANT CONSTRUCTION

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Ark., El Dorado—City, G. R. Crosley, mayor, plans constructing municipal light and power plant and distribution system and equipment. $600,000.

Calif., Arlington—Nevada-California Electric Co., 3771 8th St., Riverside, G. M. Wills, genl. supt., plans constructing steel new substation, accommodating two banks of transformers and two incoming 33,000 volt circuits. Immediate installation to be two 1,000 kva. transformer banks, future installation is provided for in design to permit capacity of two 33,000 kva. banks. $40,000.

Calif., Los Angeles — Southern California Edison Co., 601 West 5th St., plans repairing flood damaged power facilities, here and vicinity, principal damage is to hydro-electric plants in San Bernardino Co. To exceed $400,000.

Colo., Craig—City defeated $100,000 bonds to finance construction of municipal light and power plant. E. T. Archer & Co., New England Bldg., Kansas City, Mo., engrs.

Conn., Derby—Derby Gas & Electric Co., M. Eckhardt, pres., 22 Elizabeth St., altering and improving power plant, incl. new boiler and turbine, Housatonic Ave., by separate contracts. $80,000. Private plans.

Conn., New Haven—United Illuminating Co., 128 Temple St., plans completed by R. W. Foote, 185 Church St., constructing 2 story, 30x100 ft. and 30x30 ft. brick, steel, concrete power sub-station, pile founds., George St. To exceed $40,000.

Florida—Clay Electric Co-operative Assn., Inc., F. Dowling, pres., Keystone Heights, plans constructing power lines, $163,000 funds allotted; also generating plant at Keystone Heights, $42,000 funds allotted. R.E.A. Wash., D. C., allotted funds.

Ga., Augusta—City, c/o R. E. Allen, mayor, making plans furnishing, installing pumping equipment for additional water supply. $175,000. Robert & Co., Bona Allen Bldg., engrs.

Idaho, Twin Falls—Dpt. Interior, Bureau Reclamation, Wash., D. C., plans constructing 500 kw. unit on Minidoka Reclamation project in southern Idaho to furnish power for Milner low-lift irrigation district, an 8,700 acre tract between Burley and Twin Falls. $400,000. Funds included in Interior Dpt. appropriation bill now pending in Congress.

Ia., Hampton—City Council authorized expenditure of about $15,000 for new city electric plant equipment, incl. additions.

Ia., Larchwood—Bids between May 15 and June 1, by City, M. C. Solon, clk., for one 200 hp. diesel engine, changing of present distribution system from direct to alternating current, etc. $28,000. Buell & Winter Eng. Co., 508 Insurance Exchange Bldg., Sioux City, engrs.

Kan., Plainville—City, c/o City Clerk, defeated $100,000 bonds, constructing municipal light and power plant building and equipment, distribution system, etc.

La., Bossier City—City, c/o Mayor, defeated $400,000 bonds to finance construction of municipal light and gas plant. Project will probably be abandoned.

La., Breaux Bridge—Breaux Bridge Sugar Co-Operative Inc., S. Angelle, secy., Breaux Bridge, soon takes bids constructing power house and electric power equipment. $185,000. E. A. Rose, 816 Howard Ave., New Orleans, engr.

Mich., Chesaning—Union School Dist., C. Cheeney, secy., plans by B. C. Wetzel & Co., 2317 Dime Bank Bldg., Detroit, constructing 2 story, basement, brick, steel, stone school and power house. $150,000.

Mich., Eaton Rapids—Tri-County Electric Co-op. plans constructing electric power plant. $75,000.

Mich., Milford—Ford Motor Co., Dearborn, plans by Shreve, Anderson & Walker, 914 Marquette Bldg., Detroit, constructing rein.-con. power house and dam. Est. about $60,000.

Minn., Le Center—City, c/o L. T. DeGonda, city clk., plans constructing electric light and power plant, generating equipment, distribution system. $120,000 to $140,000. May hold bond election soon to vote on $70,000 bonds.

Mo., Chillicothe—J. R. Taylor, chn. Bd. P. Wks., soon lets contract remodeling building, installing new boiler and switchboard for municipal power plant, for City. $300,000. Henrici-Lowery Eng. Co., 114 West 10th St., Kansas City, Mo., engrs.

Neb., Columbus—City plans constructing new complete light and power system. $250,000. Bond selling delayed.

Neb., Cozad—City, approved $275,000 bonds to purchase privately owned plant of Western Public Service Corp. of Scottsbluff, Neb., provided same can be done at reasonable price, otherwise to construct municipal plant and distribution system. R. Fulton, 2327 South 19th St., Lincoln, engr.

Neb., Grand Island—City Light & Power Dpt., plans purchasing new boiler and auxiliary equipment for power plant. $50,000.

Neb., Grand Island—City, c/o Clerk, soon takes bids constructing addition to power plant. Black & Veatch, 4706 Bway., Kansas City, Mo., engrs. G. Shattuck, Grand Island, archt.

Neb., York—City, c/o City Clerk, voted $475,000 bonds, constructing municipal light and power plant building, equipment and distribution system, etc. C. R. Fulton, 2327 South 19th St., Lincoln, engr.

N. Y., Ogdensburg—City City Hall, plans constructing municipal power plant. $700,000. Plans application for Federal funds.

O., Newton Falls—Judge McVicker has upheld the right of the Village to sell $150,000 in bonds for constructing municipal light plant, for City, D. M. Bailey, Jr., mayor, and dismissed an action filed by Ohio Pub. Serv. Co. seeking a restraining order.

Okla., Anadarko—City voted $90,000 bonds to enlarge light plant. N. Kunkel, Anadarko, engr.

Okla., Duncan—City made preliminary plans constructing another unit to light plant. $50,000.

Okla., Fairview—City voted $60,000 bonds to enlarge diesel light plant. E. M. Evans, Fairview, engr.

Okla., Lindsay—City made preliminary plans constructing addition to light plant. $30,000. G. Alkire, mayor.

Pa., Reading—City plans constructing electric generating plant to supply current for city pumping plants and municipal buildings. Burns & McDonnell Eng. Co., 307 East 4th St., Cincinnati, O., engrs.

Pa., Wellsboro—Wellsboro Electric Co., G. H. Hill, genl. mgr., taking bids for expansion of light and power plant and distribution system, also for additional equipment for generating plant. $150,000. Private plans.

Pa., White Haven—White Haven Sanatorium Assn., Dr. F. A. Craig, pres., c/o Henry Phipps Institute, 7th and Lombard Sts., Phila., Miss Mary G. Marren, secy., Real Estate Bldg., Phila., making plans and soon takes bids reconditioning and constructing 40x40 ft., brick, steel, concrete power house addition, 30 ft. high. $125,000. C. E. Bonine & H. F. Sanville (Assoc.), Land Title Bldg., Phila., engrs.

Tex., Hempstead—City, J. C. Calhoun, secy., voted bonds constructing municipal electric light system and power plant. $90,000.

Tex., Liberty—City, c/o T. Calhoun, mayor, receives bids about June 15 (extended date), constructing power and light plant, incl. complete power and light plant and street lighting system, three 225 hp. engines, transformers, power house, etc. $114,000. P.W.A. project.

Tex., San Antonio—City, C. K. Quin, mayor, will not construct municipal electric power and generating plant, due to slum clearance and other projects. $2,770,000. Project abandoned. I. Ewig, city engr.

Va., Alexandria—Virginia Pub. Serv. Co., Charlottesville, plans constructing electric power sub-station. $60,000.

Wash., Ellensburg—Kittitas Co., soon lets contract furnishing one stationary Diesel power plant. To exceed $1,000. R. P. Ryker, Courthouse, engr.

Wis., Manitowoc—Municipality soon takes bids constructing electric power plant. $45,000.

Alberta—Consolidated Mining & Smelting Co., Ltd., 215 St. James St. W., Montreal, Que., making plans constructing hydro-electric development on Yellow Knife River. Initial cost $250,000.

N. S., Halifax—Nova Scotia Power Comn., H. S. Johnston, ch. engr., Provincial Bldg., constructing Diesel electric power plant, at Isle Madame, by day labor. $40,000. All machinery, materials and equipment will be purchased by owner.

Ont., Bobcaygeon — Municipality preparing plans constructing power plant on Little Bob River, initial capacity 300 hp. $75,000. C. Grant, clk. Light & Power Comn., Town Hall, engrs.

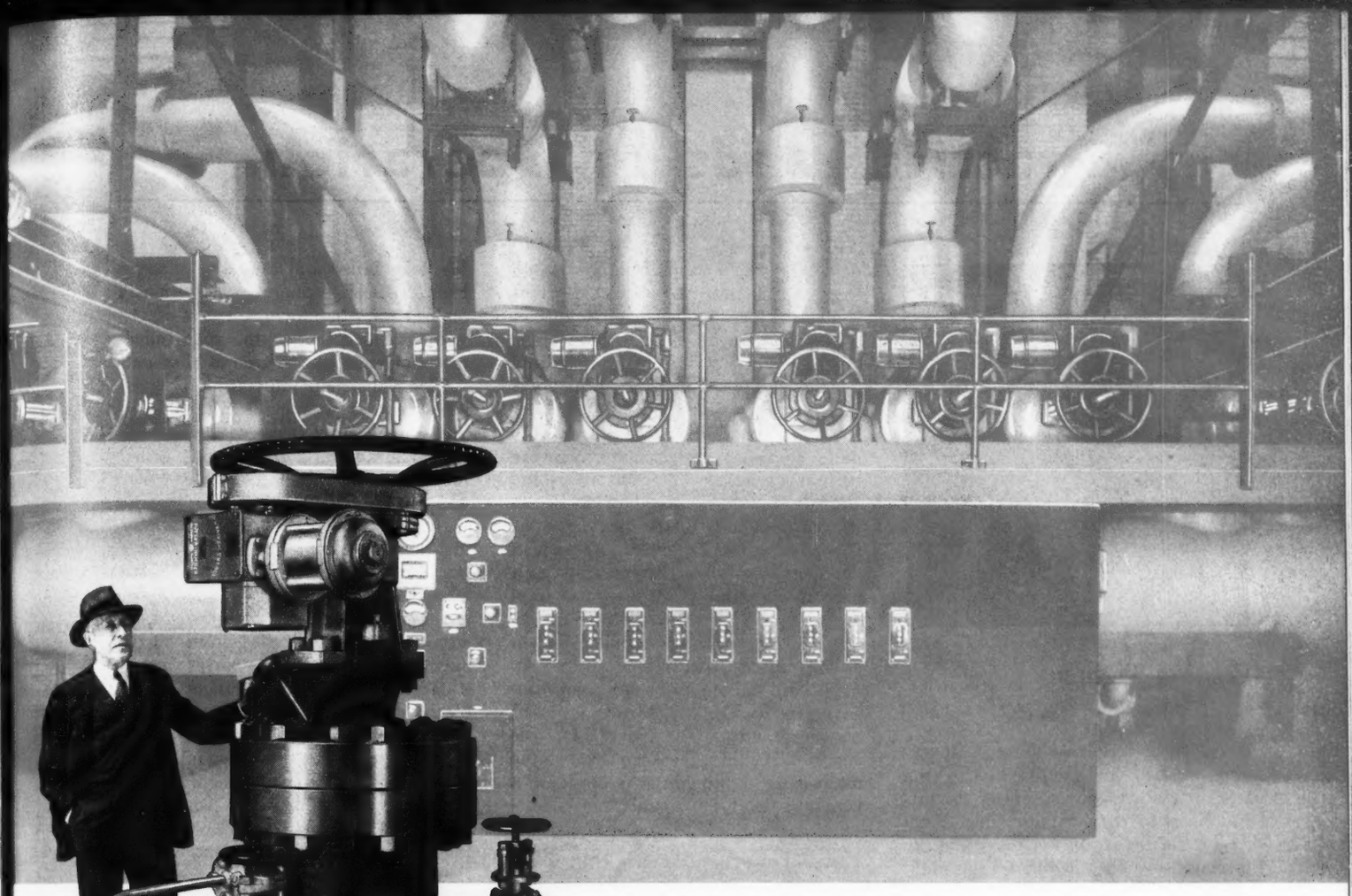
Ont., Brewers Mills—Gananoque Light, Heat & Power Co., Gananoque, soon takes bids constructing 130 ft. power dam and plant capable of developing 1,200 hp. of electricity on Rideau River, near here. $30,000. J. M. Campbell, pres.

Ont., Heron Bay—Ontario Paper Co., owned by Chicago Tribune Co., 435 North Michigan Ave., Chicago, Ill., U. S. A., plans constructing power house, power lines, wharf and pulp handling plant, Black River. $200,000. Private plans.

Ont., Mud Lake—McIntyre Porcupine Mines, Ltd., Timmins, prepared plans and soon takes bids constructing new power house. Est. about $75,000. Private plans.

Ont., Thorold—Ontario Paper Co., Ltd., taking bids constructing pulp handling plant, power house, and wharf. $200,000. Private plans.

P. E. I., Charlottetown—Provincial Dpt. P. Wks., soon takes bids supplying power machinery. $50,000 voted.



CHECK THESE EXCLUSIVE CUTLER-HAMMER FEATURES

SPECIFIC METALLURGY. Steam temperatures at 900° and above eliminate the possibility of haphazard choice of valve materials. C-H units also employ the specific alloy and treatment best suited to the function of each part. Write for specifications.

MOTOR INSULATION. C-H valve unit motors have class B asbestos and mica, flame-proof insulation, standard for a 75°C rise.

AUTOMATIC DISENGAGEMENT. Any operating unit which "brakes" itself on the valve seat subjects the valve to heavy strains. Therefore, C-H employs automatic disengagement of driving unit at exact moment of seating. Driving unit then runs free until its inertia is spent.

TIGHT SEATING OR POSITION SEATING. Some types of valves demand tight seating. Others properly should be position-seated. C-H valve control provides either method.

READY ALWAYS FOR MOTOR OR MANUAL OPERATION. For a power plant valve operating unit to fulfill its purpose, it should be immediately operable either by hand or by motor. In C-H units, neither type of operation can interfere with the other. Remote control is always available in case of emergency.

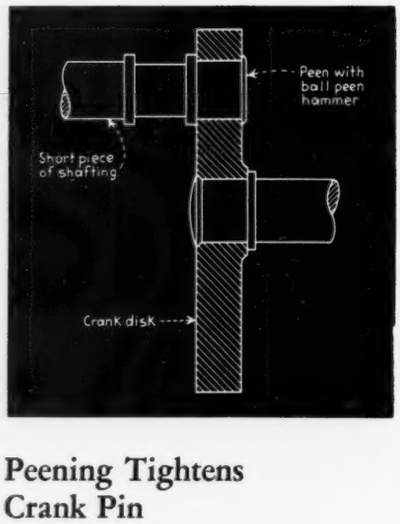
VALVE OPERATING UNITS Engineered the "Power Plant" Way

The advanced stage of power plant practice is due largely to the openmindedness of its personnel . . . their friendliness to technological progress. Behind this is a constant insistence upon a tremendous margin of reserve in every unit of equipment.

So it is wholly natural that Cutler-Hammer Valve Control units should win widespread preference. No matter from what angle C-H units are studied, they demonstrate the characteristic "power plant" engineering . . . in their specific metallurgy of all parts, the unique motor construction, the entirely exclusive operating features which make their performance outstanding. Consult with the nearest Cutler-Hammer representative. CUTLER-HAMMER, Inc., *Pioneer Manufacturers of Electric Control Apparatus,* 1209 St. Paul Ave., Milwaukee, Wis.

CUTLER-HAMMER
VALVE CONTROL
C-H

Practical Aids to Operation



Peening Tightens Crank Pin

A CRANK PIN became loose in an engine disk. As facilities were not readily available for renewing the pin, I decided to try tightening it. First, with a small square, I checked the pin to make sure that it still was at right angles to the disk. The pin was found to be in proper relation to the disk. If this condition had not existed, I don't think the pin could have been tightened, and if it could have, that the bearing would operate without excessive heating.

The pin was tightened by holding a piece of shafting against its outside end and peening the inside end with a ball-peen hammer. Naturally, one would expect that this would be a temporary job to keep the engine running until a proper repair could be made. However, one job of this type that I know of operated for nearly 5 years before it had to be renewed.

Sloat, Calif ROY L BROWN

Makes Under-Sized Drill for Over-Sized Hole

KNOWLEDGE of what cannot be done in grinding a twist drill saved much time on the job of replacing a ruptured gate valve in a 6-in., 250-lb natural-gas line. When the repair crew got on the job it was found that, although line pressure was as stated, a 600-lb gate valve had been used with 1-in. bolts. To use same size bolts, it would have been necessary to drill holes at least that size in the flanges of the new valve, which had been sent out without bolt holes to permit accurate alignment in the field.

Since line pressure was only 250 lb, it had been assumed that the $1\frac{1}{8}$-in. drill bit carried would be large enough to accommodate the bolts, so that something had to be done because it was a long way back to headquarters. We set up a portable emery wheel and converted the $1\frac{1}{8}$-in. bit to what was in effect a $1\frac{1}{16}$-in. drill bit, simply by offsetting the point $\frac{1}{16}$ in. from the drill center line, and leaving the correct angle for the short cuting lip. Fig. 1 shows the shape of the original drill and Fig. 2 the shape of the point after grinding. As such a drill is hard to start accurately, a correctly ground $1\frac{1}{8}$-in. drill was used to spot-in the prick-punched holes until a full cone was made. When started in this depression, the $1\frac{1}{8}$-in. drill had no tendency towards wandering because both lips began to cut at once, and thus balanced the side strain. Drilling feed was not quite as fast as it would have been on a standard point, but time lost in humoring the bit was but a fraction of that involved had a larger drill been essential.

FIG.1

FIG.2

Such a plan of offsetting drill points, though not advocated to eliminate a full stock of drill bits, will work in an emergency, but not in a job where pilot holes have been drilled. The different angles of the two cutting edges, in such a case, encourage wabbling and result in a spiralled hole, if the bit is not broken long before the job is finished. On the gate-replacement job, the entire two sets of holes were drilled through the valve flanges with only one retouching of the cutting edges after encountering a hard spot in a flange.

Longview, Texas M T PATE

Neglect Causes Blowoff-Valve Failure

THE YOKE on an outside screw-and-yoke blowoff valve failed recently in a large power plant. An operator was blowing down a boiler preparatory to starting the day's run. While he was closing the valve next to the boiler, the yoke failed and the valve plunger blew out. Escaping water seriously scalded the operator. A study of the valve revealed that, if the yoke failed, the plunger would be free to blow out.

This valve had lubrication plugged holes, but it was evident that these plugs had never been used although the manufacturer's instructions called for lubrication every time the boiler was cleaned.

Neglect was a contributing factor in this accident because excessive strain had to be applied to the valve wheel to move the plunger. To guard against such occurrences it would be advisable to require steel yokes on all outside screw-and-yoke valves where it is possible for the plunger to be blown out if a yoke happens to be defective.

Boiler inspectors and those in charge of power-plant operation should watch carefully to see that plant equipment is in safe operating condition. Time to correct potential-accident conditions is before accidents happen and not after someone is injured or killed.

Binghamton, N. Y. C W CARTER, JR.

Old Truck Serves Maintenance Crew

THE electrical maintenance crew in one industrial plant considers the service truck one of their main tools. There are several miles of overhead 2400-volt distribution line, plus trans-

Suitable for ALL PRESSURES *without change of valve or seat*

Small size . . . Hardly larger than a pipe union . . . a fraction of the size of ordinary traps. ½-inch trap measures 2¼ inches; 2-inch trap, 4¾ inches long.

Light weight . . . Requires no support other than the pipe line, eliminating the bother and cost of complicated brackets and other structures. ½-inch trap weighs only 1⅛ lbs., 2-inch trap weighs 8½ lbs.

Low cost . . . It is frequently cheaper to install a new Yarway trap than to try to repair an old, worn, ordinary trap.

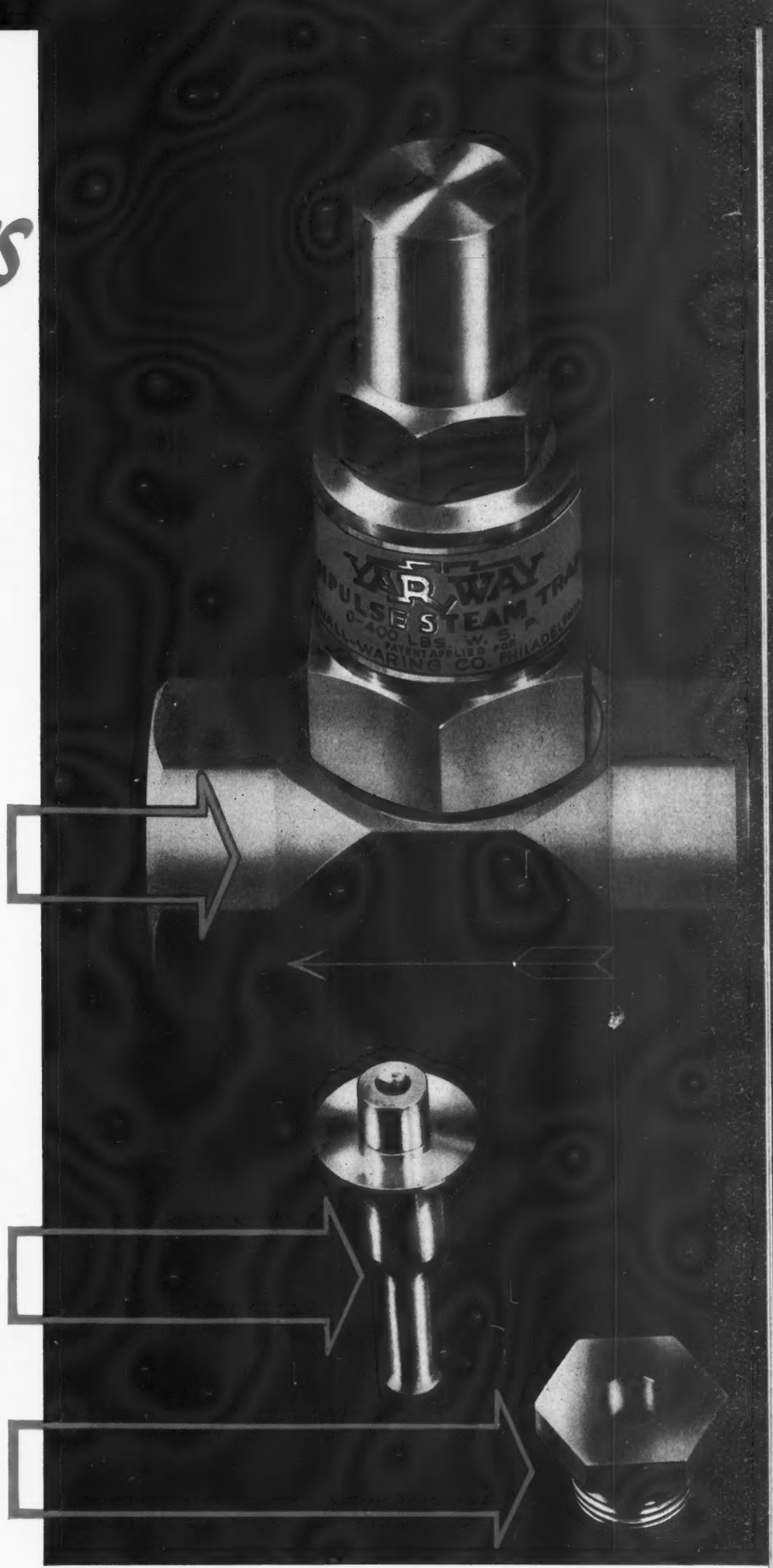
Easily installed . . . Straight line piping, together with small size and light weight of trap, simplifies the installation, makes a neater, better-looking job and leaves clear space around equipment.

High efficiency . . . Faster heating and greater sustained heating efficiency, because this trap opens wide, discharging large amounts of air and condensate quickly at the start and continuously thereafter. Small size reduces radiation loss to a negligible minimum.

Less maintenance . . . Rugged bar-stock construction throughout. Only one moving part—a simple valve "F". Valve and seat of stainless steel, heat-treated for long life and severe service; body and bonnet of cold drawn steel, bright cadmium plated inside and out for permanent rust-free finish; control cylinder of stainless steel; cap of tobin bronze.

Standardized . . . Six sizes, ½" to 2", serve practically all trap requirements without change of internal parts. Standard construction (described above), for pressures up to 400 lbs., stainless steel trimmed for pressures up to 600 lbs. *Same valve seat for all pressures without change.*

YARNALL-WARING COMPANY
100 Mermaid Ave. Philadelphia



YARWAY

ANOTHER YEAR OF WIDESPREAD POPULARITY

IMPULSE STEAM TRAP

formers, low-voltage lines, motors, and the electrical system in a good many company houses. Expense would not justify a utility line truck, so an old truck was fitted with a standard delivery-truck body and a roof top about 9 ft above ground. This roof provides shelter for tools and electrical apparatus and serves as a working platform for overhead lights.

All poles with oil switches or fused cutouts are stepped from a point about 10 ft from the ground to the top. Almost every pole is near a roadway so that the truck can be parked near the pole, as in the photo, and the electrician can conveniently climb up from the roof deck. Where lights on poles are replaced, the same procedure saves considerable time. Since steps start at 10 ft above ground level, there is never any trouble from boys climbing the poles.

With proper rigging, the truck is used for lowering or raising transformers on the poles or on elevated platforms. It can also be used for pulling lines tight when necessary and pulling cables into a conduit. In one case, where an old line had to be taken down, a reel was bolted to a rear wheel, truck jacked up, and wire reeled in quickly. When a new pole is put in, a line rigged to the old pole pulls up the new one, saving time and labor.

Sayreville, N. J. W H HUMPHREW

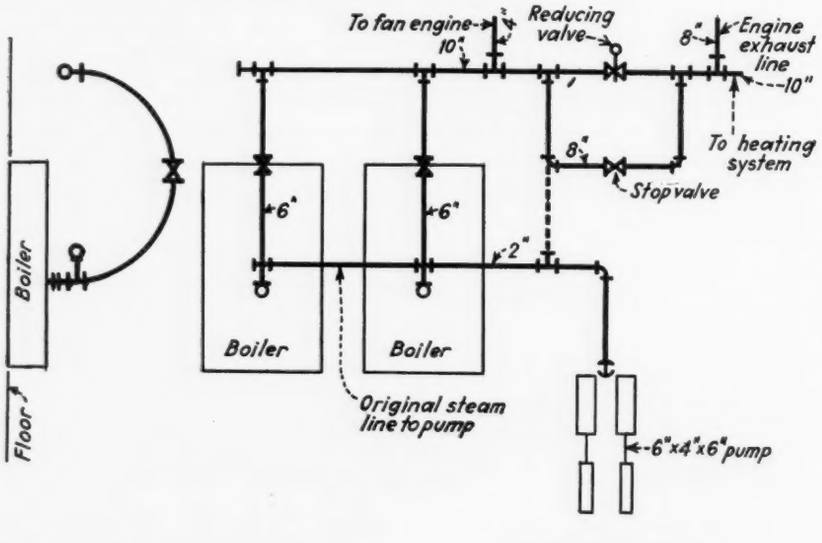
Steam Connection and Not Pumps at Fault

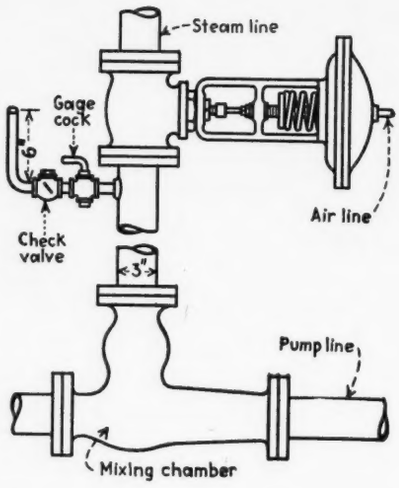
TROUBLE with a steam boiler-feed pump that baffled plant operators for several years was finally solved on a hunch. This heating plant had two boilers operating at 30-lb pressure supplying steam to a vertical engine belted to a large fan. Engine exhaust was sufficient for the heating coils, except in extremely cold weather, when additional steam was supplied through a reducing valve with a bypass. All condensate from the building was returned to a receiver over a duplex steam pump that returned it to the boiler. The diagram shows the piping layout.

The steam line was taken off the main pipes just over the boilers to obtain dry steam at as high pressure as possible for the pump. This arrangement looked ideal, but in operation the pump would not work fast enough to return all the condensation to the boiler, thus wasting much to the sewer. Then, cold water had to be fed direct to the boiler for makeup. The pump was thoroughly examined and adjusted, but did not help matters. Even though complete overhaul did not improve conditions, we all diagnosed the trouble as in the pump and decided it was a jinx. Then we installed a pump that had been working satisfactorily and had the same trouble. We then knew the trouble was not in the pump but in the steam line. Examination showed the line clean and open. Pump connection to the main line was then changed to one end of the bypass around the reducing valve, as shown by the dotted line. This was done just as an experiment, but to our surprise, when the steam was turned on, the pump started to work in a lively manner and for over a year has returned all condensate to the boiler and is one of the best working pumps we have.

Our theory is that when the pipe was connected to the main steam pipes at the boiler, steam velocity was so high that it reduced the pressure at the opening to the pump line. The greater demand for steam, the higher the velocity and the less pressure in the pump line. But when the piping was changed to the 8-in. bypass, slower steam velocity in the 10-in. line gave a pressure higher than that at the boilers.

Kansas City, Mo. W H BURLEIGH





Valve Quiets Steam-Water Mixer

IN AN AIR washer used as humidifier, a 3-in. 8-lb steam-line, intermittently operated from a dew-point control, caused a great deal of hammering, which loosened the pipe joints. A small gage cock and check valve installed just below the steam valve (see figure), acted as a sniffing valve to break the vacuum. The gage cock regulates the amount of air necessary to prevent noise. This change eliminated all noise and lengthened life of the valve piping.

Boston, Mass FRED A CARTH

Dangers of Obstructed Blowdown Piping

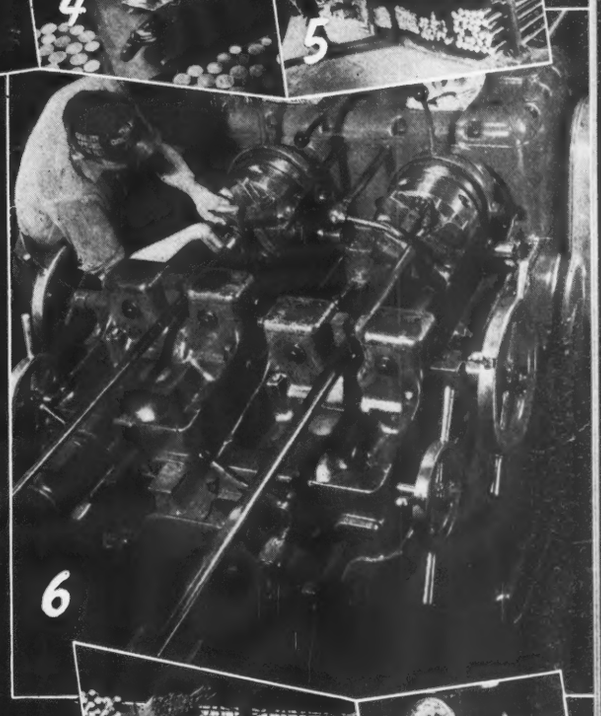
BLOWDOWN lines on steam boilers lower water level in the boiler if it accidentally becomes too high; keep sludge accumulations from causing trouble; maintain concentration of solids in the boiler water below a predetermined maximum, by blowing off a portion of the water and replacing it with fresh; and drain the boiler. Obstruction of the blowdown line halts these important operations, yet I have visited a number of plants where the blowdown line was completely obstructed.

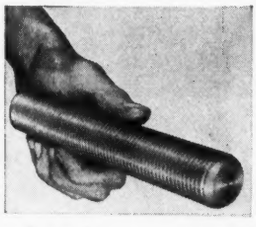
Failure to blow a boiler down at regular intervals causes a constantly increasing proportion of solids in the boiler water. When this concentration passes a critical point for the water temperature, carryover of solids in the steam increases rapidly, causing serious erosion of pipe fittings and prime-mover parts. A heavy deposit of sludge may collect on heating surfaces of a water-tube boiler exposed to high gas temperatures, with the probable climax of tube failures.

In an hrt boiler, the blowdown pipe is exposed to high temperatures in spite of protective piers. In addition to

Choosing Materials for Edward Valves - No. 7 of a Series

Edward Bolting must be right





ALLOY steel for studs for Edward bolted bonnet valves has to pass a stiff examination before admission as qualified stock. Years of study have developed a series of inter-related tests which indicate to a high degree of accuracy, in advance of use, the salient characteristics of each heat of material. Accompanying pictures show some of the routine tests. One picture indicates a special investigation to which studs are subjected from time to time. Nuts used in connection with Edward studs naturally have to possess comparable — but not identical — physical stamina.

• • •

The Edward Valve & Mfg. Co., Inc.
EAST CHICAGO INDIANA

After checking (1) the incoming stud stock for Brinell hardness, bar by bar, coupons (2) are cut from each end of each bar, which are (3) etched in acid to reveal internal structure for examination (4) under a microscope. On the basis of this test, rejection is made for piping, seams, segregation, or undue inclusions. Accepted material is then placed (5) in storage racks, awaiting threading (6) by tangential type chasers which produce smooth finish, with accurate form and true pitch, to required fit. See operator checking work with latest type roller snap precision gages. Fully threaded bars are stored (7) until ready for cutting to length in automatic machines, where ends are chamfered and squared and threads are combed for removal of burrs. Before assembly in high pressure valves, individual studs are classified as to Brinell hardness (8) so that proper stress may be applied in setting up the nuts. A frequent but not routine physical test (9) involves proportional limit determination on a completed stud.

EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

dangers of carryover, sediment may accumulate on the bottom of the shell, directly over the fire, and cause dangerous overheating. As the blowdown pipe is exposed to high temperatures, it is possible for one filled with sludge to overheat and rupture.

In internally fired boilers, such as the locomotive, vertical-tubular, and horizontal-firebox types, the blowdown pipe is away from the high temperature zone, but dangers from carryover and sediment deposits on the crown-sheet over the fire still exist. In addition, sludge may accumulate in the waterlegs, causing overheating with possible dangerous results.

Neglect to blow boilers down at proper intervals is the most common cause of obstructed blowdown lines. These intervals should be determined by an accurate concentration test of the boiler water, and practical observation of the extent of sediment accumulation. Intervals vary widely with different types of boilers, load, and feedwater. Some conditions require a boiler blowdown every four hours and others, once a day.

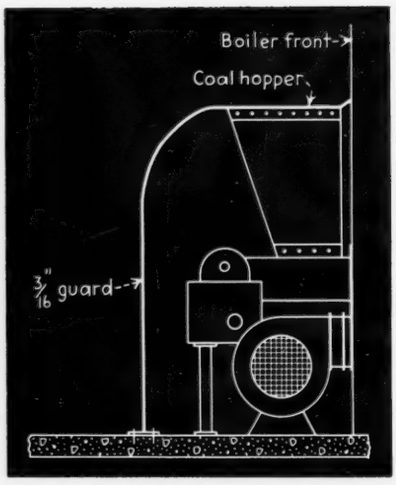
A sudden detachment of a considerable amount of loose scale may block the blowdown line. Scale removal should be accomplished gradually if it is done by feedwater treatment when the boiler is in service. Avoid treatment that removes scale quickly. A somewhat more remote cause of obstructed blowdown line is failure of some part of the blowdown valves. The corrective step in this case is obvious. Should the blowdown line become obstructed from any cause, take the boiler out of service until the line is clear.

Cleveland, O. A G WIGGINS

Sheet-Metal Guard Protects Stoker

STOKERS are installed under small boilers primarily to reduce fuel consumption, increase capacity and to eliminate smoke. In many of these installations, automatic coal-handling equipment may not be economically justified and it is still necessary to fill the stoker hopper by shoveling. In spite of this, labor required is substantially less than when fuel is fired by hand, because of reduction in quantity of fuel burned and the infrequent attention required by the stoker fuel bed.

Among the disadvantages of manual handling of fuel from floor to stoker hopper are troubles experienced in keeping boiler room and stoker mechanism clean. While dust can be avoided by using dustproofed coal, or by moistening where a small quantity of water will not interfere with burning characteristics, there is still the problem of preventing droppings from the scoop falling on stoker moving parts. These coal particles cause wear of bearings, and if drawn into the forced-draft fan, block air passages and either reduce available air or increase power required to drive the fan. Where much fuel falls into hard-to-reach corners around and behind the stoker mechanism, it must be removed frequently in order to prevent accumulations that will interfere with operation and detract from general appearance.



These troubles are avoided in one small boiler plant by placing a sheet-metal guard over the stoker retort and drive, as in the figure. This guard is made of 3/16-in. iron and extends the full width of the hopper front. Sufficient clearance permits lubrication, adjustment of coal feed and air dampers, and minor maintenace. When major maintenance is needed, the guard can be easily removed.

Roanoke, Va. S H COLEMAN

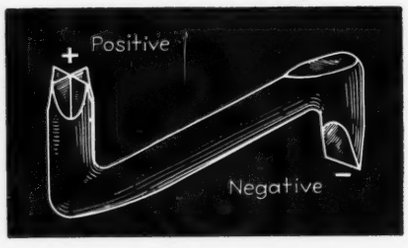
Ammeter Solves Paralleling Problem

OUR power-generating equipment includes a 100-kw and two 200-kw, 225-volt, compound-wound dc units. Several years ago, they gave considerable trouble by not properly dividing the load between them. Any attempt to divide the load proportionately caused severe sparking at the brushes.

As a means of finding the cause of the trouble, we installed a portable recording, shunt-type ammeter in the 100-kw unit equalizer and found a circulating current of 50 amp between this unit and one of the 200-kw machines. Adjusting the field rheostats to give proper voltage and zero current in the equalizer caused a slightly disproportionate loading of the two units, but commutation and voltage regulation were improved.

We then permanently installed a 150-amp differential, shunt-type ammeter on the switch-board, with the shunt in the equalizer of the 100-kw unit, as in the figure. Paralleling is now done by adjusting the field rheostats until this ammeter reads zero, and the voltage is correct. A slight unbalancing of load results, but never more than 50 amp.

Dartmouth College, Hanover, N. H. A L WATERMAN
Asst Chief Engineer

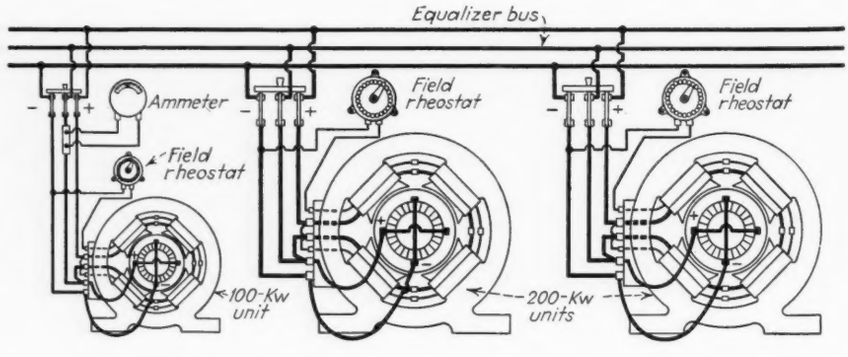


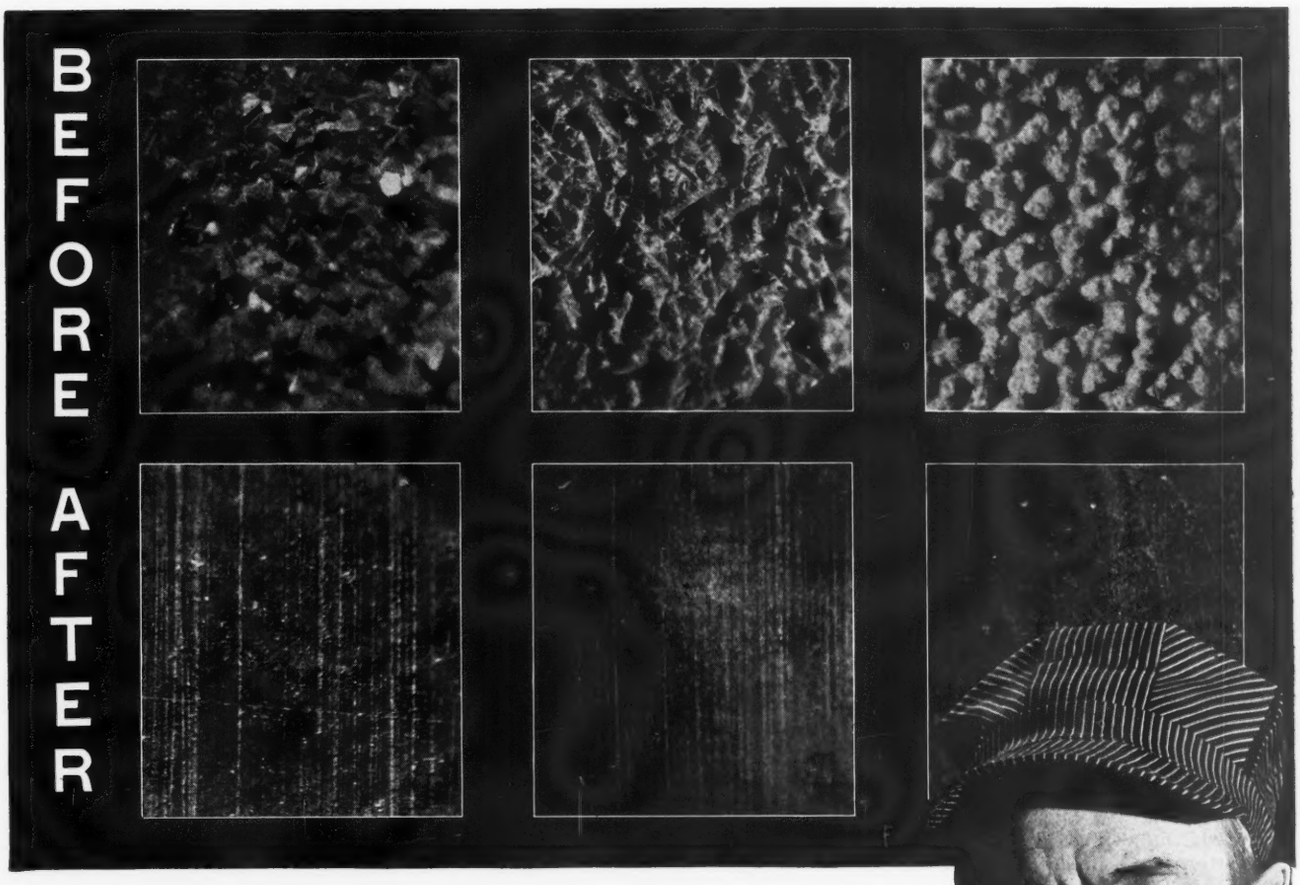
Handy Positive and Negative Stamp

THERE is always a need for definite marking of positive and negative poles, connections or terminal posts. Any shop man can make a double-end stamp from a piece of round tool steel by forming it at opposite right angles on each end and filing it as in the figure.

The positive end can be made with a small square or a three sided file. On the straight rod, above each marking, file a flat space where the tool is to be struck with the hammer, and then temper to a dark straw color.

Penacook, N H C H WILLEY





Here's What We're Talking About!

REDUCED to the bare essentials, this is what tells the story. One row of pictures shows photomicrographs of boiler tubes coated with scale (three different kinds); the other shows tubes clean and ready to transmit heat with maximum efficiency. Between the two stands the Nalco System—responsible for the improvement.

You can have this kind of improvement for your whole boiler plant. Adoption of the Nalco System of Feedwater Treatment requires no additional capital investment. Total cost is often less than present expenditures for chemicals alone. Have one of our field engineers make a survey of your requirements. No obligation. NATIONAL ALUMINATE CORPORATION, 6222 W. 66th Place, Chicago, Illinois.

ANY WATER **NALCO SYSTEM** ANY PRESSURE

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico,* should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

What's New in Plant Equipment

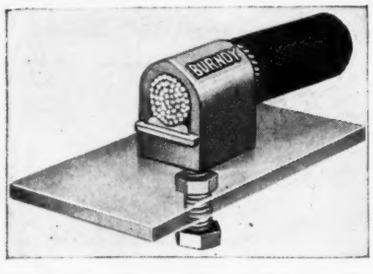
Vari-Speed Control

AUTOMATIC and remote control for Reeves vari-speed motor drives, known as fluid-pressure control, can be used to automatically regulate speed from pressure variation, as in a stoker feed on a boiler, maintenance of constant fluid pressure in a pipeline or tank upon which there is a variable demand, etc. Complete control consists of a bellows-shifting mechanism mounted on motor drive, and adjustable pressure-reducing valve located where desired, auxiliary valves if needed, and connecting pipes. Speed of shifting depends on fluid used. Air is fastest, and will shift the control over widest (6:1) ratio through its complete speed range in from 2 to 4 seconds.

Reeves Pulley Co, Columbus, Ind.

Clamp Connector

TYPE KPF clamp consists of a cast copper body through the bottom section of which a hole is tapped. A ½-in. bolt passes through the hole in the copper bar and into the tapped-body hole where it forces pressure bar against cable. By tightening nut assembled on the bolt,



joint is clamped to bar and protected against vibration. Accommodates a range of cables and can be pivoted upon bolt to permit cable tap-off at any angle from bar.

Burndy Engrg Co, Inc, 459 E 133rd St, New York, N. P.

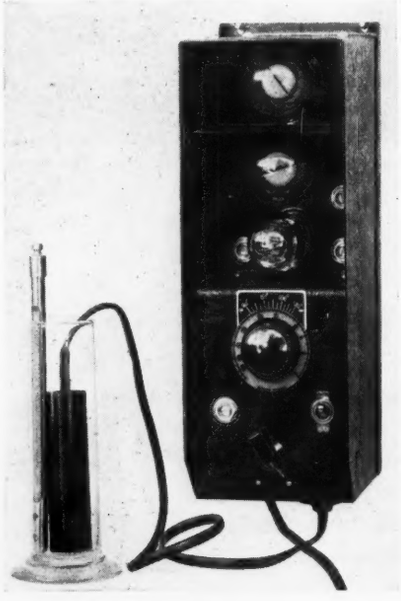
Air Hose

AIR hose, with inner tube of gas-oil-proof synthetic rubber, has two or three braids of long-staple cotton cord. Between these are placed sheets of live rubber which vulcanization forces into the cord. This construction, with addition of heavy abrasion-resisting cover of black rubber, gives great strength. Smooth bore permits free flow. Made in sizes from ¼ to 2 in.

Manhattan Rubber Mfg Div, Passaic, N. J.

Nalco Blinker

THIS instrument acts as a continuous indicator of correct solids content in condensate, steam, feed or boiler water, and for checking the quantity of dissolved solids in any water containing from 1 ppm to 700 grains per gal. Commonest use is to continuously check solids in main steam header by taking a continuous sample of steam through a cooling coil and reducing to a temperature below 100 F. The condensed steam is then passed through an electrode connected by wires to the Blinker which may be

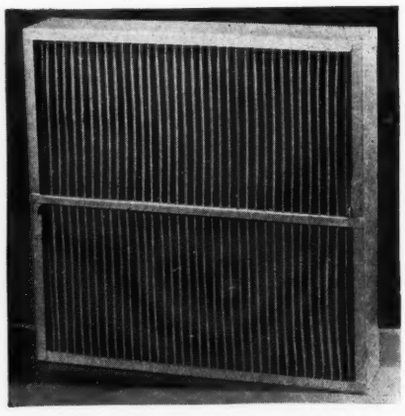


in any convenient location, such as engineer's office, lab, boiler room, etc. Any water, such as blowdown, feedwater or condensate, may be checked in the same manner. Each instrument consists of the Blinker proper, a stationary electrode for condensate, and two portable electrodes—one for condensate and one for boiler water. Stationary electrodes for measuring boiler water are extra.

National Aluminate Corp, 6216 W 66th Place, Chicago, Ill.

Air Filter

"WIRE-KLAD" air filter has wire mesh reinforcing filtering medium so that filter can be cleaned indefinitely by high-pressure air or vacuum. Several kinds of filtering media to suit varying conditions are available, most usual being cotton or a wool felt-like material known as



"Feltex". Three standard depths: 2, 4 and 6 in., and four standard sizes: 20 x 20, 16 x 20, 16 x 35, and 20 x 25 in. Is flame resisting, meeting National Board of Underwriters requirements.

Staynew Filter Corp, Rochester, N. Y.

Oil Seal

"SPLIT-KLOZURE" oil seal consists of a cut-open, composition sealing element or packing ring molded into cross-sectional shape resembling a modified V, to which is bonded, under pressure, a finger-type spring. The sealing element and spring are combined into one piece and handled

as a single unit. Is dense, non-porous, grainless, resilient, oil-resistant, and can be installed without dismantling the machine. Regularly supplied with steel springs; for water applications, however, beryllium copper springs are supplied.

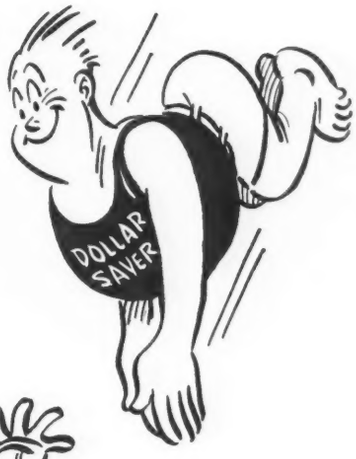
Garlock Packing Co, Palmyra, N. Y.

Motor-Starting And -Braking Control

THREE-BREAKER combination contains forward, reverse and braking oil circuit breakers. Each breaker is electrically operated with an independent solenoid mechanism. All three breakers are both electrically and mechanically interlocked, so that neither forward nor reverse breaker can be closed unless brake con-

A DOLLAR SAVED IS A DOLLAR EARNED

. . . during these days of thrift!



During this period of low production and curtailed profits, boiler plants may be operating at reduced capacity—but *they are still operating!*

Even though the factory may be working only a few days a week, important dollars can be saved *seven days a week* in the boiler plant.

With profits curtailed *any* savings are *important* savings. And a dollar saved is a dollar earned—a dollar that can be *added to profits!*

A sure way to save important dollars is to make certain that you have *correct boiler water control* in your boiler plant.

The evils that develop from incorrect control of boiler water invariably lead to heavy expense when they are neglected. To neglect these evils *now* may mean forced boiler "outage" and heavy expense *later,* when you are back in normal production.

Thousands of boiler plants—large and small—everywhere, are being protected against these evils by using Buromin and Hall Laboratories water conditioning services. They have assurance of maximum protection against *any and all* boiler water troubles.

Investigate this protection for your plant!

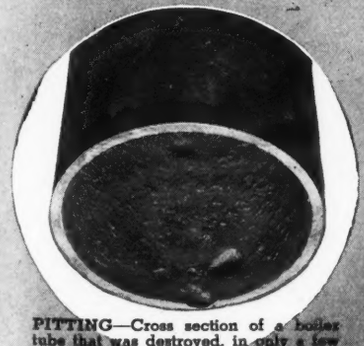
A DOLLAR SAVED IS A DOLLAR EARNED!

THE BUROMIN COMPANY, 300 Ross Street, Pittsburgh, Pa.

SCALE—A thin scale in this tube, acting as an insulation, prevented the water from carrying away the heat fast enough. Overheating caused the tube to "blow out."

EMBRITTLEMENT—Tough steel fails like brittle glass when improperly conditioned boiler water allows "caustic embrittlement" to start.

CARRY-OVER—Boiler water belongs in the boiler. When boiler water carries over with the steam, superheaters frequently plug up like this one.



PITTING—Cross section of a boiler tube that was destroyed, in only a few months, by pitting. Correct conditioning of the boiler water would have prevented this destruction.

AVOID THESE EVILS WITH

When you note some of the evils that develop from incorrect control of boiler water, you can more fully realize the importance of avoiding these evils. They invariably lead to heavy expense when they are neglected . . . such expense as replacements, repairs, and lost time due to power plant shutdowns.

BUROMIN

THE BUROMIN COMPANY
300 Ross St., Pittsburgh, Pa.

Gentlemen:

We understand that, without obligation, you will make a study of our boiler water and give us recommendations that may mean worth while savings.

Name.....

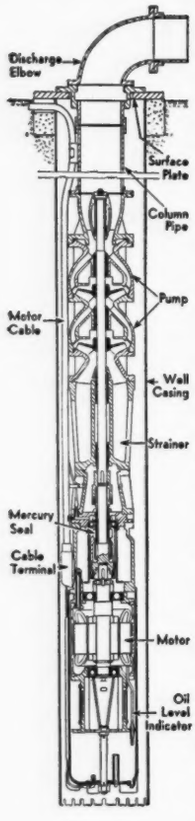
Position..... Company.....

Address.....

tacts are open, forward and reverse breakers cannot be closed together, braking contacts cannot be closed while either forward or reverse breakers are closed, and neither forward or reverse breakers can be tripped open without closing contacts of braking breaker. Breakers are 25,000-kva rupturing capacity, 7500 volts, 600 amps, with silver-to-silver contacts.

Westinghouse Electric & Mfg Co, E Pittsburgh, Pa.

Submersible Pump



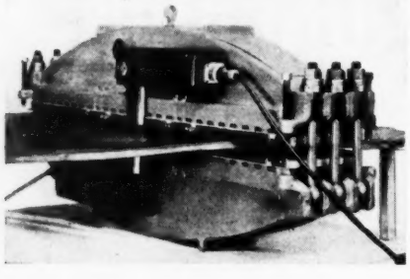
DEEPWELL turbine pump has motor below turbine bowels. Short propelling shaft and long, small-diameter motor. Turbine and submersible motor form compact unit that is attached to and supported by discharge pipe. Submarine armored cable and small copper oil tube, form only connection (aside from discharge pipe) between pumping unit and ground surface. Water is sealed out at top by mercury in a rotating cup attached to motor shaft. Cylindrical sleeve around motor shaft, with one end attached to motor casing and other end submerged in mercury, seals off water and motor oil on their respective sides.

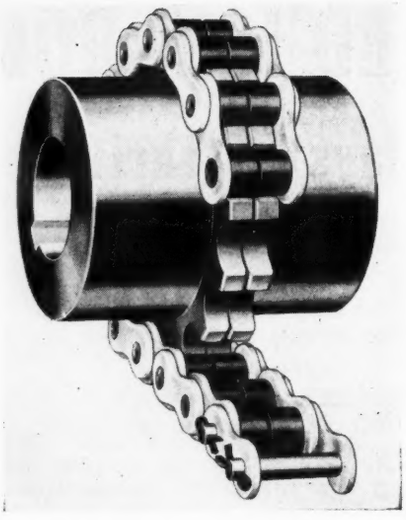
Byron Jackson Co, Dept 120, Los Angeles, Calif.

Belt Vulcanizer

LIGHT-WEIGHT vulcanizer for belts up to 60 in. wide weighs 1650 lb and has total wattage of 5000. Is similar in appearance to Goodrich double-platen, water-cooled type, except that it has only three hinged bolts at each side instead of six. Platens are 65 in. wide and 12 in. long. This makes it possible to place vulcanizer at a 10-deg angle on a 60-in. belt, at a 22-deg angle on a 54-in. belt, and at a 30-deg angle on a 48-in. belt. Can be furnished for either 110 or 220 volts, but no single machine is adaptable to both voltages.

B F Goodrich Co, Akron, Ohio.





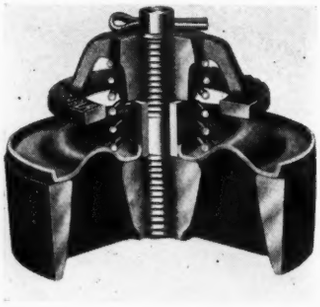
Flexible Coupling

TYPE RCB coupling consists of two cut-tooth sprocket wheels connected by a piece of specially constructed single-width finished-steel roller chain, using a recently patented divided-roller feature. Divided roller provides independent roller action for each sprocket, and as contact between roller and sprocket causes roller to revolve on its bushing, any tendency to scuff rollers and sprocket teeth is said to be avoided. Two fittings, 180 deg apart, permit packing housing with grease, without dismantling.

Link-Belt Co, 307 N Michigan Ave, Chicago, Ill.

Pump-Valve Service

OPEN-TYPE guard allows unrestricted flow, eliminates possibility of spring clogging, protects spring and correctly limits valve lift. Stud is kept from wearing by a sleeve which also provides rigid support



for guard, which is removable for inspection of valve parts. This valve service may be used on any type of reciprocating pump, at all temperature-pressure combinations, and can be supplied completely fitted and ready to install.

Durabla Mfg Co, 114 Liberty St, New York, N. Y.

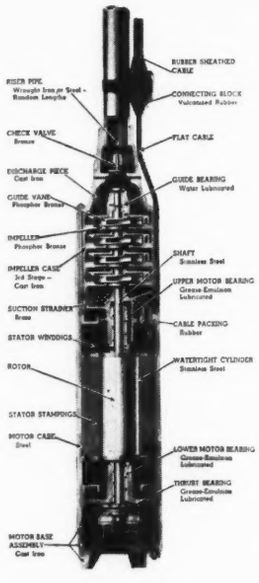
Insulating Cement

No. 1 Insulating Cement, for boilers, drums, ducts, valves, breechings, etc, is effective up to 1800 F. Applied on a clean surface, it adheres immediately, forming continuous blanket of insulation without joints. Said to have high covering capacity with low volume shrinkage. When equipment is to be replaced, cement may be removed, mixed with water and used again.

Baldwin-Hill Co, 514 Klagg Ave, Trenton, N. J.

Deep-Well Pump

UTA PUMPING unit consists of vertical centrifugal pump direct connected to submersible vertical motor, suspended on riser pipe to operate below water in well. Waterproof cable conducts current to submersed motor. Motor can

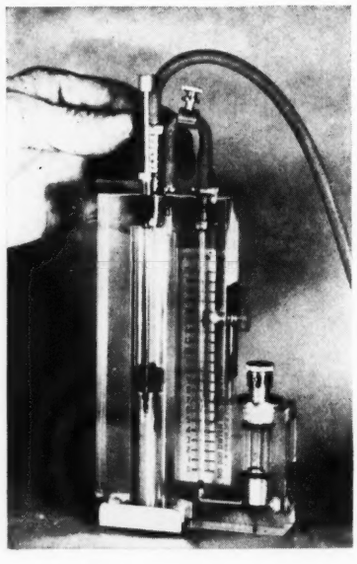


be furnished for either 60 or 50 cycles ac, single or 3 phase. Rotor operates in water, but stator is protected from water by patented rustproof, stainless-steel cylinder. For industrial and air-conditioning purposes.

American-Marsh Pumps, Inc, Battle Creek, Mich.

Pocket CO_2 Indicator

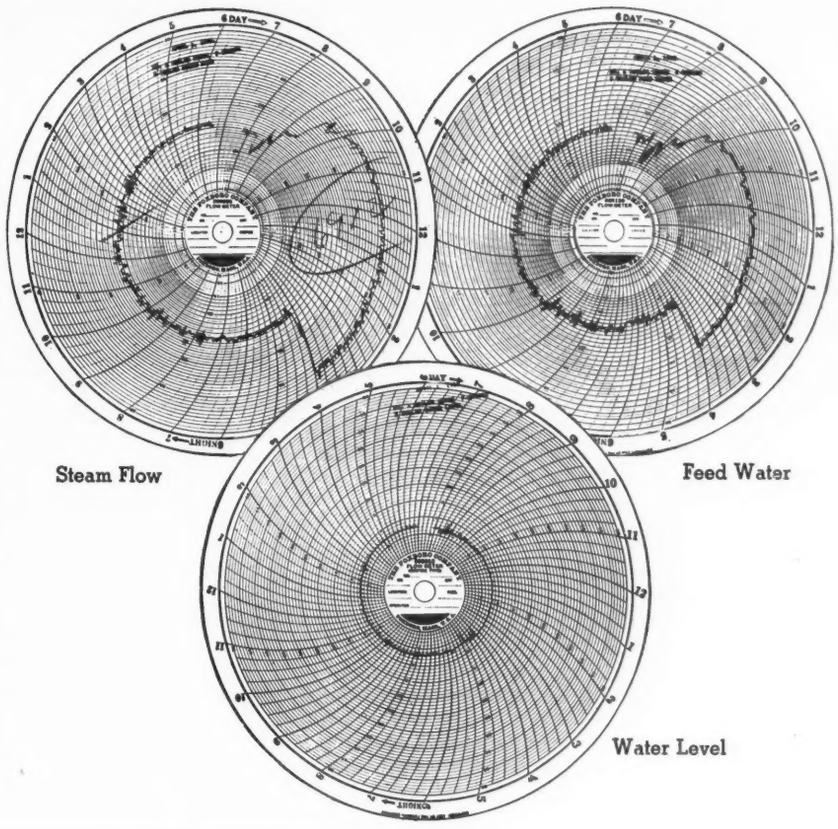
INDICATOR, complete with carrying case and accessories, weighs less than three lb. Tests are made while indicator is



FLOWMATIC on a High-Pressure Refinery Boiler

These charts are from a well-known oil refinery. They show steam flow, water input and water level as recorded on a 600-pound pressure Riley Steam Generator equipped with the COPES Flowmatic Regulator. Firing is with acid sludge or gas, and normal evaporation runs as high as 350,000 pounds per hour. The water level is carried one inch higher at the peak load of 360,000 pounds per hour than at the light load of 242,000 pounds per hour. Note the close water level control throughout the 24 hours.

The Flowmatic installation is all outdoors. The simplified steam-flow type COPES was installed, cut into service and adjusted by the plant personnel to give these results. There was no need for special service. In fact, factory service is rarely requested by any user of the COPES Flowmatic Regulator.



Steam Flow

Feed Water

Water Level

Charts Prove You Can

Close water level control is comparatively easy where loads are steady. But where loads vary widely, or swing rapidly, you can be sure of closer level control with the new COPES Flowmatic—the simplified, two-element steam-flow type of feed water regulator. Write for descriptive Bulletin 409-A. Its eight pages are filled with helpful information.

NORTHERN EQUIPMENT CO., 611 GROVE DRIVE, ERIE, PENNA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY . . . . REPRESENTATIVES EVERYWHERE

Get closer boiler water level control with the new

COPES

FEEDS BOILER ACCORDING TO STEAM FLOW•AUTOMATICALLY

FLOWMATIC

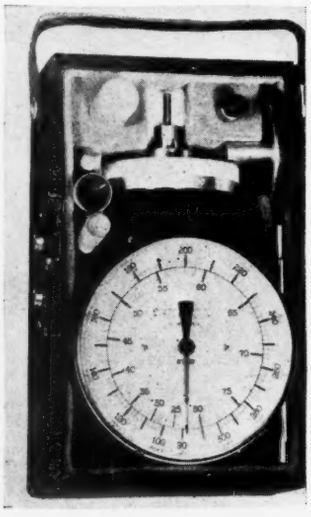
★ REGULATOR

held in hand or in clip provided in carrying case. Gas sample is pumped in with a dozen strokes of aspirator bulb while plunger is held down. Reading is taken from mercury column after absorbing unit has been raised and lowered.

F W Dwyer Mfg Co, 565 W Washington Blvd, Chicago, Ill.

Hand Tachometer

HAND makes two revolutions in each speed range instead of customary one. Three measuring ranges: 25 to 300 rpm, 250 to 3000 rpm, and 2500 to 30,000 rpm,



all engaged by turning knurled ring. Cross-pendulum type results in "dead beat" hand indications.

Coats Machine Tool Co, Inc, 110 W 40th St, New York, N. Y.

Pressure Indicator

FOR measuring peak pressure in internal-combustion engines or other machines in which pressures occur in successive cycles of the same form. Essential parts are a piston exposed to engine pressure, a helical tension spring against which the piston acts and tension of which is adjustable, and a neon-light circuit with a contact switch operated by piston to indicate any movement of the latter. To make measurement, rotate vulcanite ring nut below scales until neon light stops flickering. This indicates that

spring tension is just sufficient to balance maximum cylinder pressure which can be read off directly from scales. Standard model reads up to 1200 lb per sq in.

Bacharch Industrial Instrument Co, 7000 Bennett St, Pittsburgh, Pa.

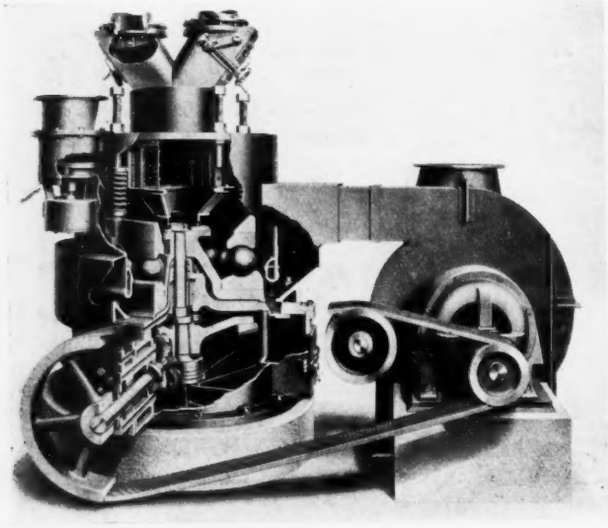
DC Air Circuit Breaker

MAIN contacts have semi-flexible stationary portions while moving contact is solid. Mechanism is mechanically trip free from cooling solenoid or operating handle so that breaker will open immediately if an attempt is made to close it against extreme overload or short circuit. Silver-plated main contacts; tungsten composition arcing tips; air dashpots, for easy closing and opening, absorb energy of moving parts. Single-pole breakers made in either pedestal or panel-mounted types in current ratings 2000 to 10,000 amp up to 750 volts dc.

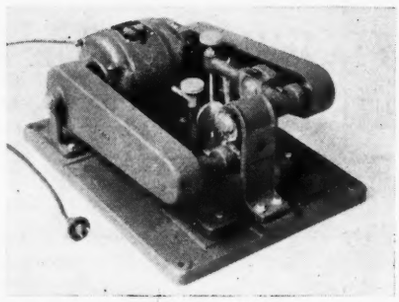
Westinghouse Electric & Mfg Co, E Pittsburgh, Pa.

Coal Pulverizer

TYPE E pulverizer uses ball-bearing principle of pulverizing common to all B&W Type B pulverizers, and supplants the latter in a certain range of sizes, 2.0 to 13 tons per hr. High capacity for given size, and power consumption as low as 9 kwhr per ton of Pittsburgh seam coal pulverized to pass 65% through 200-mesh, result from outward radial flow of coal and improved classification of fines. Improved ball material and increased capacity give low maint. costs.



Babcock & Wilcox Co, New York, N. Y.



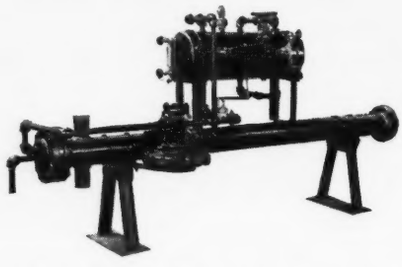
Wire Stripper

MOTORIZED brush-type wire stripper cleans and strips cotton-, silk-, enamel-, string-asbestos-covered wire, fine "litz" wire and removes gummy insulation embedded in stranded wires. A thumb adjustment screw varies distance between brushes for various sizes of wire, and an adjustable stop behind brushes fixes length of stripping.

Ideal Commutator Dresser Co, 1025 Park Ave, Sycamore, Ill.

Blowdown System

UNIT blowdown system combines flash tank mounted on heat exchanger with automatic control of blowdown flashing into tank. Blowdown is proportioned to

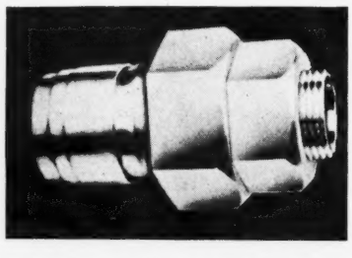


makeup, keeping boiler water at constant predetermined concentration. Unit comes complete with only piping connections to be made on the job.

Henszey Co, Watertown, Wis.

Pipe Connection

"MULTI-SEAL" pipe connector was developed in answer to demand for a method of attaching pipes to containers without having to get on inside. Connector is inserted in hole, and then action nut is tightened. May be used



on steam, gas, oil, water and air lines and will withstand high pressures. Can be installed in 5 min. by one operator working from outside only.

Multi-Seal Mfg Co, 123 N Jefferson St, Chicago, Ill.

(Continued on page 120)

STANDARD OIL COMPANY'S
STANOCYL
STEAM CYLINDER OIL
cut oil consumption in half at this plant
"We not only solved the problem of oil carryover in the exhaust steam, but StanoCyl reduced oil consumption about 50%."
This experience at a northern paper mill is typical of StanoCyl installations. This plant operates four 24 x 48 Corliss engines. The immediate problem was the elimination of excess oil in the exhaust steam used for heating. This oil was fouling the system and causing considerable maintenance trouble. StanoCyl "D" was recommended to remedy this condition.
Under the supervision of a Standard Lubrication Engineer this oil was installed and oil feed gradually reduced. Finally, when oil carryover had been practically eliminated, it was found that oil consumption had been cut in half. Inspection of valves and cylinders, however, showed excellent lubrication. Solving the maintenance problem had brought an even greater saving in actual oil costs.
There is a definite reason for the low consumption records of StanoCyl. With its more complete atomization, less oil is required to reach and lubricate even remote engine parts. It clings to cylinder surfaces longer, again reducing the amount of oil required for adequate lubrication. Let a Standard Lubrication Engineer demonstrate these facts on your engines. Let your cost records prove them. Call your local Standard Oil (Indiana) office or write 910 S. Michigan Ave., Chicago, Ill.
Copr. 1938, Standard Oil Co.
THE RIGHT LUBRICANT • PROPERLY APPLIED • TO REDUCE COSTS
STANDARD OIL COMPANY (INDIANA)
LUBRICATION ENGINEERING

Readers' Problems

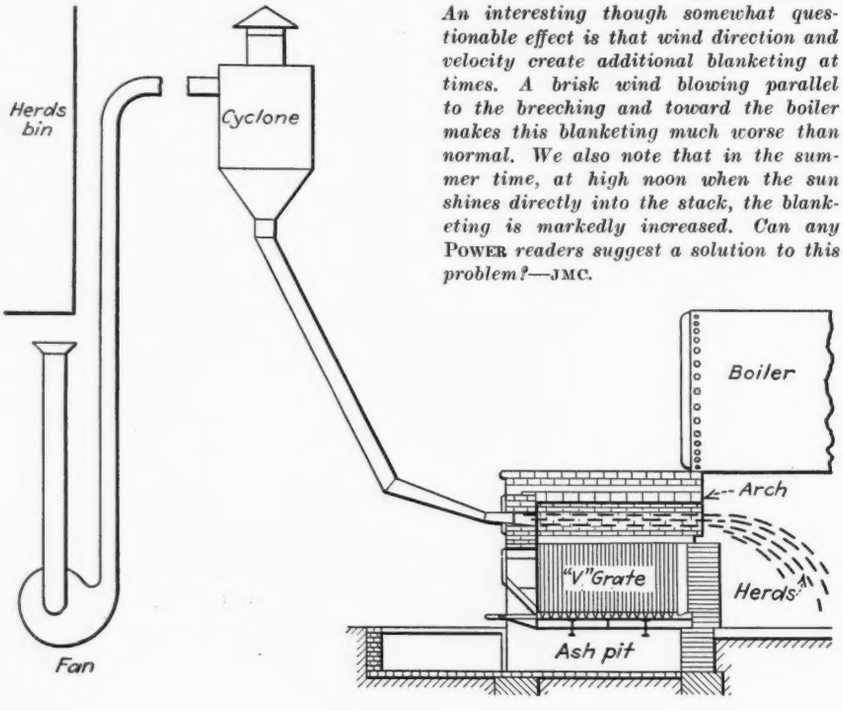
Questions for Our Readers

Waste-Fuel Plant

Question 1

WE ARE BURNING *"herds" or "shives", the residue from the manufacture of hemp fibre, having the consistency of sawdust. The boilers are 72-in. x 18 ft hrt's of 1500 sq ft each. Four are installed, all served by a 75-ft brick stack, only about 4 ft square at the base. Only one boiler is now used, at about 100% rating. The present method of burning is illustrated in the sketch. The furnace is a Dutch oven having "V" grates with a Murphy stoker. Herds are blown into the furnace. Coal must be burned at all times, and if we want to force the boiler we have to feed considerably more coal to burn completely the heavier supply of herds. There is a good deal of backfiring, especially when feeding the herds heavy, and at times the heat from the furnace ignites the coal in the hoppers. We blame this backfiring on poor draft.*

We plan to remodel this plant and would like to get suggestions from POWER *readers who have had experience in burning herds or similar fuel. We would like to avoid burning coal at all times, and to burn the herds most economically. It seems to us that the amount of air is insufficient, and we have no means of regulating it, except what comes in from the fan, as the damper in the uptake has no effect due to the low chimney. Suggestions for low-cost improvements will be extremely helpful.*—VTK



Pumps in Series

Question 2

WE HAVE *two volute pumps, one single-stage developing 234 ft TDH at 1750 rpm and the other 2-stage developing 210 ft TDH at the same speed. Can these pumps be connected in series to get the combined head of both pumps, and if it can be done, which pump should be used as the first stage?*—WML

Suitable answers from readers will be paid for if space is available for publication.

Soot Blowers Blanket Fire

Answers to April Question 1

The Question

IN OUR BOILER *the soot blowers blanket the fire to the extent of causing smoke, gas, and often flame, to emerge from the fire door instead of going out the stack. We are using a Murray 4120-sq ft horizontal tubular boiler, which is fired from the rear due to its peculiar location in the plant. The breeching leading from the stack is approximately 4 x 6 ft and 50 ft long. The stack is 125 ft high. The boiler is fired with an Iowa 1-in. screening, on a Hoffman Fyrite stoker.*

We have attempted to assist furnace draft and force the gas into the breeching by opening two of the fixed blowers that point parallel with the flow of gas, to boost the draft during the time of soot-blower operation. At times we feel this does some good, but at other times it seems to have no effect whatever. An interesting though somewhat questionable effect is that wind direction and velocity create additional blanketing at times. A brisk wind blowing parallel to the breeching and toward the boiler makes this blanketing much worse than normal. We also note that in the summer time, at high noon when the sun shines directly into the stack, the blanketing is markedly increased. Can any POWER *readers suggest a solution to this problem?*—JMC.

Steam Jet Increases Draft

WHEN OPERATING the soot blowers in our water-tube boiler, using wood waste and oil for fuel, smoke and flame would come out the fire door and feed hole. This was quite a serious fire hazard, as there was danger of particles of burning shavings being caught in the chain conveyor and carried back to the fuel bin.

The trouble apparently was lack of draft, so we ran a ⅜-in. steam line into the stack about 6 ft above the boiler. This line goes to the center of the stack with an elbow and nozzle discharging straight upward. The nozzle is made of monel with a ⅜-in. hole. Pipe and fittings inside the stack are extra-heavy brass for long wear. The nozzle is clamped to an iron brace bolted to the sides of the stack. The control valve is near the soot-blower valve and the fireman turns the steam on the nozzle at this point before operating the soot blowers.

Smoke and flame from the fire doors during soot blowing have been entirely eliminated, and draft is increased from 0.45 in. to 0.60 in. This should work for JMC, and is worth trying. Experimentation will develop the best location and nozzle size.

Pittsburgh, Cal. M L LINCOLN

Several Suggestions

IN MY OPINION it stands to reason that when live steam is blown between the tubes from several nozzles, a pressure is built up in the flues so that even with wide open damper, smoke, gas, and backfiring will be seen at the fire doors. If JMC's boiler has any kind of sensitive draft indicator connected with the different passes, this will show what happens during soot blowing.

Some tips on avoiding this trouble as much as possible follow: (1) In a battery of boilers, give the load to other boilers. Shut down all except one burner, or with coal, cut down the intensity of the fire. Blow tubes with wide open damper. (2) With only one boiler, pick a low load period, boost steam pressure as high as possible, get all set for blowing, cut burners or fire temporarily, and let her blow.

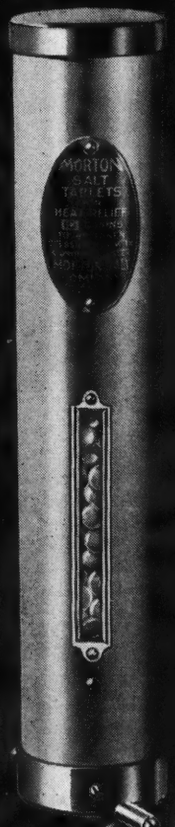
Wind conditions affect the draft, and on a hot summer day with the noon sun shining directly into the stack, the difference in specific weight of air column inside the stack and out is reduced.

Nutley, N. J. C M ZOCK

Zone Blowers

WHEN soot blowers on an hrt boiler are started, the tubes are filled with steam, which blows the soot and ash accumulation ahead of it. There is a tendency for the loose material to form a bank or slowly moving wave in the tube, par-

Stop the Daily Toll of HEAT-FAG* in Your Plant!



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*HEAT-FAG —that unseen, strength-sapping force that attacks workers and withers production and profits

Men who sweat need salt. When overheated, the body cools itself by perspiring. As we perspire, salt is lost and unless replaced, Heat-Fag results — efficiency sags — production suffers.

There is a simple, yet very inexpensive way to help stop the toll of Heat-Fag in your plant. Install Morton's Salt Tablet Dispensers and fill with pure, highly refined Morton's Salt Tablets. Put dispensers near the drinking fountains. Workers will use them — restoring the salt they so vitally need yet lose when days are hot and work is heavy. Alert plant managers the country over, with an eye to workers' health and efficiency, recognize the necessity of protecting against Heat-Fag.

The cost of a Morton Dispenser and a case of 9,000 Morton's 10 grain Salt Tablets is very small when compared to the benefits derived. Order at least one unit *now*.

Only the purest and most highly refined Salt is used in Morton Salt Tablets.

For more interesting facts on the importance of salt to your employees, write for illustrated bulletin "Heat-Fag."

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MORTON SALT COMPANY
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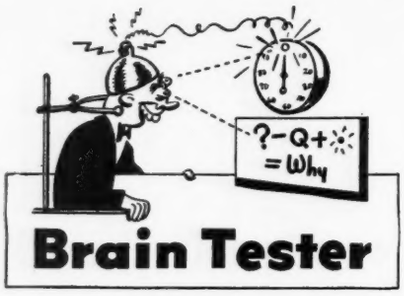


Sharpen your wits on this little problem, then check your answer with the one given on page 120.

TESTING THE HELPER

THE master mechanic liked smart helpers, so he thought up a tricky test to give young hopefuls looking for a job. Each was presented with a steel plate; the plate contained a hole one inch square, and a triangular hole with a base one inch long, and an altitude of one inch. Each also got a piece of 1-in. diameter rod, a hacksaw and a file. The instructions were simple—plug the two holes in the plate, tightly. No more than one piece of rod was to be used for any one hole.

Could you have gotten the job? How?

---

tially closing it. Area available for passage of gas is restricted, and there is not sufficient draft to force the gas through. In fact, enough backpressure may be built up to cause excessive furnace pressure with the natural escape of smoke and gas through the fire doors.

My suggestion is to blow the soot more often, so that less material will have to be moved each time. It would also help if the soot-blowing equipment were zoned, so as to operate on only part of the tubes, say one-fourth of them at a time. Under this plan, there would be much less chance of blowback, since the major part of the boiler would be working normally. Blowing should be scheduled for light-load periods when gas quantities are less.

Corvallis, Ore. W H MARTIN

Check for Leakage

IF JMC'S blowers are properly set in relation to the stoker and the breeching is free of soot accumulations or other obstructions, his trouble may be summed up in one word—leakage. This leakage may be at one or more of three points: (1) around the drum or through a broken or misplaced baffle between the uptake and the furnace space. Stack effect would seem good but uptake temperature would be high enough for leakage to be indicated by a pyrometer. Pre-supposing a clean boiler, evaporation would be poor, due to short-circuiting of flue gases.

(2) The wind effect indicates that part of the trouble is where the breeching enters the stack. Wind blowing around the stack and from a direction parallel to and opposite from the breeching creates a low-pressure area at this point. If there is a leak, an aspirating movement is set up which opposes the stack effect. This is possible with winds of even moderate velocity. (3) Leakage at the cleanout door at the base of the stack would cause the same effect as leakage at the breeching.

Menard, Ill. MARVIN WHITE

Soot Accumulations

RECORDS of JMC's plant should be checked to see if this is a recent development, or if it has been experienced ever since the boiler was installed. In the former case, JMC should look for heavy soot accumulations in the 50 ft of breeching, since this is often a serious obstruction to free flow of gas. It may be that the unburned products of combustion from the fuel used, and other combustion factors, cause a rapid accumulation of soot.

In any event, I would advise blowing soot more frequently so that there will be less disturbance of draft conditions when blowing. Baffle design should be checked to see that natural pockets for soot accumulation are few and far between. Draft obstruction can be created by accumulations in such pockets just as easily as by a blocked flue or duct.

Canton, Mass. H M SPRING

Water in Lube Oil

Answers to April Question 2

The Question

WE HAVE *a mechanical lubricator oiling the cylinder walls of each of two 8 x 8-in. ammonia compressors, and have recently identified these two lubricators as the source of water in the lubricating oil. Due care has always been taken to fill with pure oil, but on draining the lubricators on several occasions, it was noticed that great quantities of small water globules were suspended in the oil. A day or two after refilling, the same condition would reappear.*

It is difficult to account for the water and my only guess is that it condenses on the lid of the lubricators or working parts during cool weather. Or is it possible that due to the presence of traces of ammonia gas in the oil, it absorbs minute particles of water from the air, in quantities that are not visible to the eye. There seem to be no other explanations, for all oil is carefully scrutinized before a light, prior to filling. We are using Texas Co's "Capella Oil."

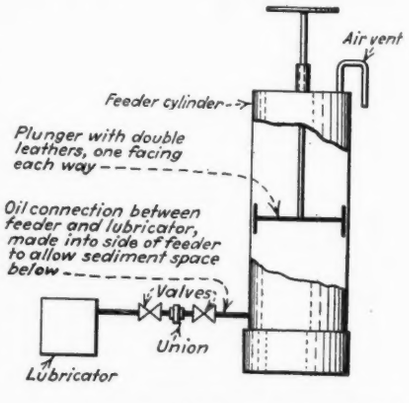
Is there a simple, inexpensive way of filtering out this finely divided moisture without resorting to costly centrifugal purifiers? We have tried passing the oil through cotton cloth, and through rayon, but with only partial success, for a portion of the water persists in coming through with the oil.—AFD

Prevent Entry of Water

HAVING centrifuged samples from several hundred drums of lube oil and having discovered entrained water in only three, I agree with AFD that the oil is probably up to standard at the time it is fed into the lubricators. Since AFD's compressors are handling ammonia, it is likely that the temperature is lower than that outdoors, and air drawn in, even though of relatively low humidity, has the humidity raised by the drop in temperature. The air may even reach the saturation point before it is gradually drawn into the lubricator to replace the oil being pumped, little by little, into the compressors. This volume of air, though comparatively small, can introduce sufficient water to cause the small water globules AFD mentions. That the "tramp" water appears as finely divided droplets tends to support the condensation theory, as water from the original containers is most apt to be found in larger bodies.

Once water enters the lubricator, it can be removed only by special filters or centrifuging, but AFD can prevent the entry of air very easily and thus exclude the water vapor whose condensation causes the trouble. One way would be to feed some inert gas (carbon dioxide or nitrogen) from a cylinder, in such a way as to maintain a pressure on the interior of the lubricator oil chamber, the normal air vent being plugged, of course.

Some years ago, the writer was chief engineer in a plant where sulphuric acid was a byproduct and where the acid fumes formed a corrosive mist in moist weather, depositing dilute acid over everything. This was excluded from the lubricators by sealing them and providing an outside source of lube oil which was filled as needed, and kept sealed against the intrusion of water- and acid-bearing air. The sketch shows a plunger in the oil-supply cylinder, loaded just enough to maintain the desired pressure in the lubricator. When supply was exhausted, the cylinder was disconnected at the union, and another, filled at a point remote from the source of contamination, was connected in its place.


Air vent
Feeder cylinder
Plunger with double leathers, one facing each way
Oil connection between feeder and lubricator, made into side of feeder to allow sediment space below
Valves
Union
Lubricator

No traces of acid damage were found on any of the enclosed parts formerly suffering from acid droplets in the lube oil. We did find it expedient, however, to wash out and carefully dry the portion of the oil feeder above the double-cupped plunger to be sure to remove any condensation occurring during the slow downward progress of the plunger.

Longview, Texas M T PATE

(*Continued on page* 118)

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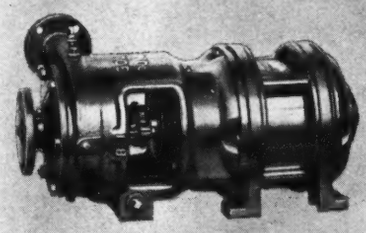

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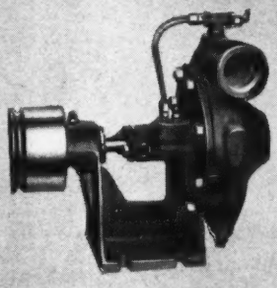
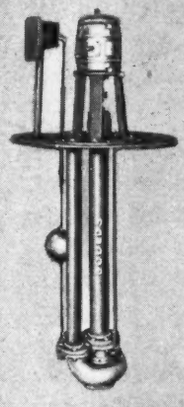
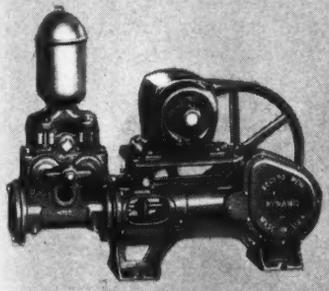


GOULDS NEW BELT DRIVEN CENTRIFUGAL PUMPS



GOULDS SUMP PUMPS



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Goulds Centrifugal Pumps are quality built, therefore last longer and effect real savings in your pumping costs.

Goulds makes scores of different types and sizes from which to select the pump that meets your particular need. Complete stocks in every principal industrial center for immediate service.

Goulds and Goulds Distributors can show you why it's good business to standardize on Goulds.

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Gettin' Thar . . .

HIRAM walked four miles over the hills to spark the girl of his dreams. For a long time, they sat silent on a bench outside her cabin, but after awhile the moon got in its licks, and Hiram sidled closer and picked up her hand. "Becky", he started in, "I got a good clearin' over thar, a team an' waggin, som kaows and shotes, an' I cal'late on buildin' a house, an,—"

Just then Becky's mother woke up and yelled, "Becky, is that young man thar yit?"

"No, Maw," called Becky, "But he's a'gittin' thar!"

You know, that's one of the hardest things for any of us to do—git thar! We hem and haw, skeediddle and skeedaddle, and meanwhile we get nothing done. There's an old Indian saying that "The way to cross a river is to cross a river." Some engineers spend months working out instruction books for equipment—while the equipment gathers dust. Others hunt and hunt for the cheapest way to modernize, but never actually settle down and place an order. Still others do a lot of fancy organization planning, while their best men get disgusted and quit. And plenty of Chiefs set down so many rows of figures to find out what power costs them that they never get around to making it cost any less.

As some author said recently, "The process of writing is the process of applying the seat of the pants to the seat of the chair." In other words, the one best way to get a job done is to get started at it. No army ever got anywhere by marking time. Don't be like Dopey the dwarf, who didn't know whether he could talk or not, because he'd never tried.

George Edwards

Engineer

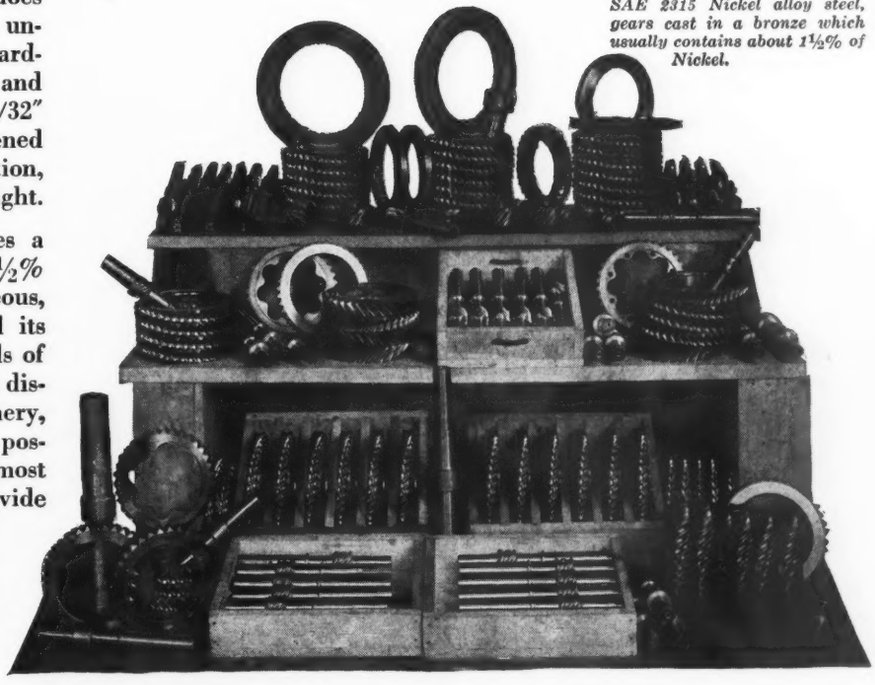
WORM GEARS THAT STAND THE GRIND AT HIGH SPEEDS AND TEMPERATURES

Improved performance of steel worms and bronze gears results from the addition of Nickel

Severe punishment is inflicted on gears by speeds of 5800 r.p.m. and up. Add to this and the heat thus generated, the additional heat of live steam, and it takes a hard, tough alloy to stand the gaff. To meet such conditions, commonly experienced in steam turbine reductions and such applications, the Baush Machine Tool Company of Springfield, Mass., uses alloys of Nickel for both worms and gears.

The worms, which are hardened, ground, and polished, are made of SAE 2315 Nickel alloy steel. This alloy does not spall or develop surface cracks under intense frictional heat. When hardened, it has an extremely tough core, and a glass-hard surface which extends 1/32" or more in depth. It can be hardened with a minimum amount of distortion, and once straightened, it stays straight.

For the worm gears, Baush uses a bronze mixture usually containing 1½% Nickel. Stronger and more homogeneous, this bronze, when stressed beyond its limits, tends to peen out at the ends of teeth, instead of failing by granular disintegration. Chilled on the periphery, these gears of Nickel alloy bronze possess increased hardness where it is most needed. Thus, worms and gears provide smooth, dependable operation and long life under unusually severe conditions of service. Consultation on the use of the alloys of Nickel in power applications is invited.

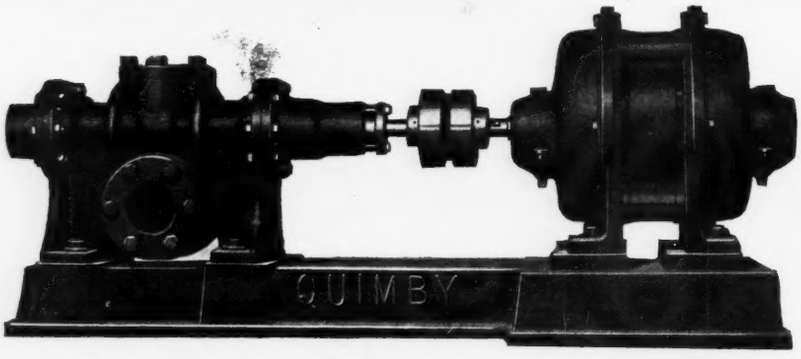


Worms and gears manufactured by the Baush Machine Tool Company, Springfield, Mass. Worms are made of SAE 2315 Nickel alloy steel, gears cast in a bronze which usually contains about 1½% of Nickel.

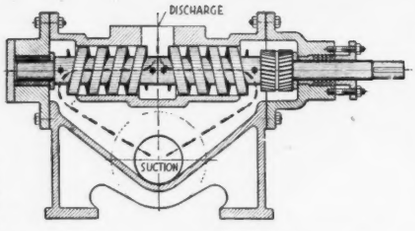
THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

QUIMBY PUMPS

for FUEL OIL SERVICE



SCREW PUMPS for High Pressure Service



Flow of liquid is away from stuffing boxes to the center insuring balanced thrust.

Built for long life and minimum service costs, these pumps provide a pulseless flow of oil and thereby insure a steady flame at the burner tip. They can also be used for transfer work and to handle many other liquids both thin and viscous.

Two parallel shafts on which are mounted four screws arranged in pairs are the only moving parts. *There is no internal contact between screws or between screws and cylinder. The screws do not drive themselves, thus wear is reduced to a minimum.*

Built in capacities from 2 to 4200 g.p.m. at pressures up to 800 lb. per sq. in. depending on viscosities.

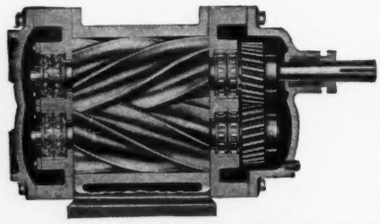
ROTEX PUMPS for Average Pressure Service

Made in capacities up to 500 g.p.m. and for pressures up to 200 lb. per sq. in. depending on viscosity.

Highly efficient units for handling oils and other viscous liquids where working pressures and viscosities do not require higher pressure screw pump units.

There are only two moving parts. Units in sizes up to 2½" employ two flat-sided elliptical rotors of two-lobe design driven by timing gears. On pumps in sizes above 3", pumping action is provided by timing gear driven single helical gear rotors. *There is no internal metal to metal contact between the rotors themselves or with the casing.*

Lobe type rotors used in smaller sizes of Rotex Pumps.



Gear in head type Rotex Pump with single helical gear rotors used in large sizes.

• • • • • • • •

The Quimby Pump Company offers equipment not only for fuel oil but for almost any process liquid. In addition to the two rotary lines described above, there are three designs of pumps for acids and corrosive liquids. The Quimby line of standard water centrifugal pumps includes vertical types either sump or non clog, horizontal type single and multistage horizontally split case, and vertically split case non clog and multivane.

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Screw ☐ Rotex ☐
Centrifugal Types
Double Suction ☐
Chemical ☐ Vertical ☐
Multistage ☐ Non Clog ☐
Side Suction ☐
Resilient Rubber Lined ☐

Readers' Problems

(*Continued from page* 112)

Heat the Oil

A SIMPLE WAY to remove traces of moisture (up to 2–3%) from lube oil, is to heat the oil to about 220 F and agitate either with air or a mechanical stirrer until a chilled sample shows no droplets of water. This method will effectively remove the water.

Philadelphia, Pa. C F KENNECK

Try Filtering

WE HAVE EOUND that it pays to recover waste oil from a number of machines around the plant. It is often desirable to keep oil from various departments separated, and with a simple oil filter in each department, this can be accomplished.

A number of economical filters are advertised. We like best a filter that allows the water to separate at the bottom, and the purified oil at the top. The filtering medium is usually waste or cotton, but where there is trouble with finely divided water or emulsified moisture, the filter can be fortified with fused, flaked calcium chloride. This can be placed in the filter medium, provided care is taken to keep the water that separates from the oil below this level. The calcium chloride will dissolve if this condition is not maintained. A simple filter of this type can be made from a couple of gage glasses, an empty oil drum and screen.

Lakewood, Ohio. J P SIMONS

Use New Oil

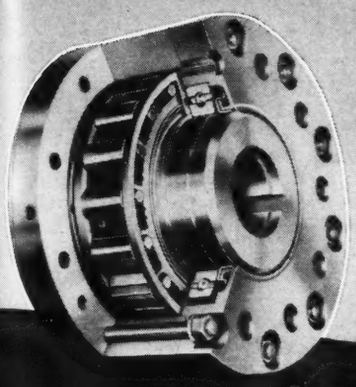
APPARENTLY oil drained from some part of the refrigerating system is being used in AFD's lubricators. This is inferred from the statement that "pure" oil is used—instead of saying that new oil is used. Oil drained from the refrigerating system will have ammonia in it, and when exposed to the atmosphere after having been under pressure, ammonia will be liberated. Release of the ammonia will reduce pressure with a corresponding refrigerating effect which will condense some moisture from the surrounding air.

Heating the oil will drive off most of the ammonia and vaporize the moisture. This oil, after filtering, is suitable for use in the compressor crankcase. However, new oil should always be used in the lubricators, since the quantity used will be small (probably enough to serve as makeup), and because used oil contains traces of ammonia which will attack brass parts of lubricators.

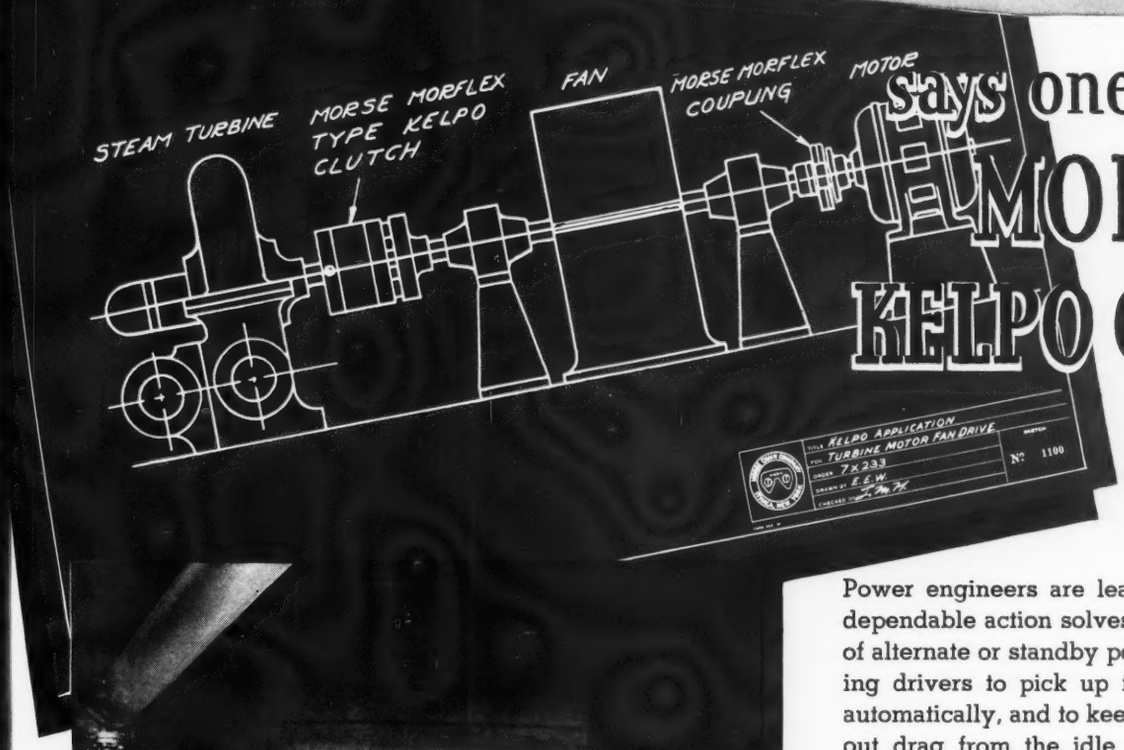
Waynesboro, Pa. H REICHENBACH

Check Valves May Leak

A POSSIBLE source of AFD's trouble is the check valves between the lubricators and the cylinder, which may be allowing a slight leakage of ammonia back



"Slickest thing in the whole plant"



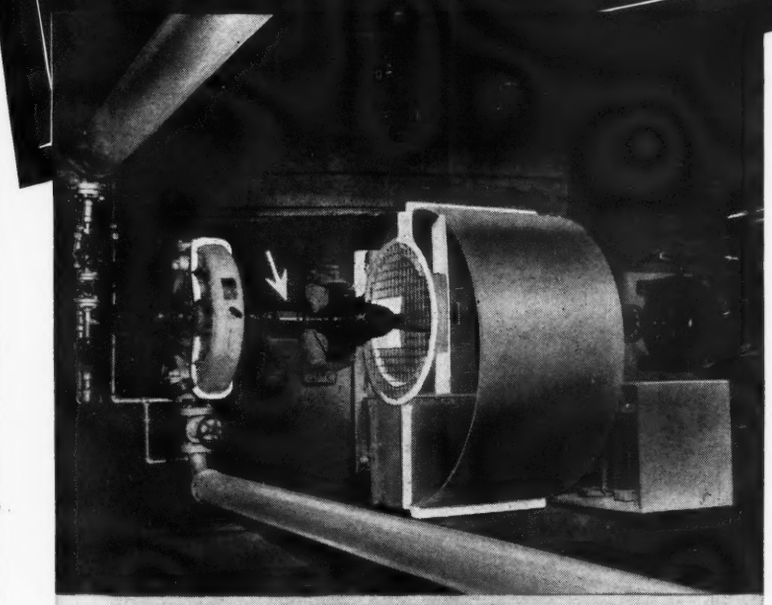
says one user of MORSE KELPO CLUTCH

IT'S one of many such comments: "Our Kelpo Clutch is the slickest thing in the whole plant!"

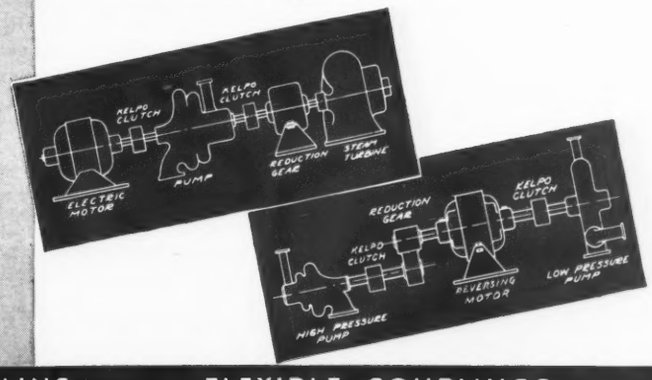
Power engineers are learning that its positive, dependable action solves many of the problems of alternate or standby power application, allowing drivers to pick up the load smoothly and automatically, and to keep the load turning without drag from the idle unit. The Kelpo saves money by eliminating power waste and by ending costly wear and tear on drives and equipment.

The Morse Kelpo Clutch is a precision mechanism with all the stamina and ruggedness necessary to "walk through" the hardest driving jobs. Its exclusive multiple cam construction grips and releases gently and without shock, yet positively as a gear. With equal ease, it free-wheels or drives for long, steady periods—or engages and releases many times an hour.

Call in the Morse man. Let him tell you the applications of the Kelpo Clutch.



The Kelpo free-wheeling clutch in this application is installed on the shaft of a fan, driven by a motor with a steam turbine as alternate power, which supplies forced draft to two traveling grate stokers. Previously, it had been necessary to turn the turbine at all times, but with the Kelpo, the turbine is idle 90% of the time, saving power and maintenance to such a degree that user says Kelpo will pay for itself in one to two years.



SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

NO OIL WATER

IN YOUR AIR LINES

you get

AUTOMATIC DRAINING

with

SWENDEMAN SEPARATORS

do this, automatically, efficiently. Made in 3 types.

Type A—used for all classes of industrial work where pressure variations are not necessary.

Type C—equipped with shut-off cock to permit of removing valve for cleaning without loss of air. A desirable feature where air is in constant use, particularly on the larger sizes.

Type D—has pressure regulator and gauge and is used when pressure regulation is essential, as in spray painting.

a real ● *Guarantee . . .*

If you are not satisfied in every respect with the operation of the Swendeman Automatic Separator, after a thirty days' trial, return it to us and we will gladly refund the purchase price.

(Also manufacturers of the Dexter Valve Reseating Machines for reseating globe valves, gate valves and pump valve seats).

THE LEAVITT MACHINE CO.

10 East River St. Orange, Mass.

BRAIN TESTER

Answer to problem on page 112.

THE boys that got the job did two simple things. First they sawed off a one inch length of rod, filing it up nice and true. Inserted sideways in the square hole, it plugged it. Using the same plug or making another, it required only two more saw cuts to finish the job. Marking a diameter on one end of the one-inch length of rod, they made two slanting sawcuts downward to the lower circumference. The resulting wedge, slipped sideways into the triangular hole, filled it completely. But the smartest lad of all bet the MM a week's pay he could plug any hole that would fit inside a 1-in. square, and won the bet.

---

through the lubricators. The affinity of ammonia for water then explains the presence of water in the lubricators.

If the oil is reclaimed from the oil separator, it should be piped to a closed drum, the top of which should be piped to the suction side of the compressor. To drain the separator, the valve between the separator and drum is opened. After draining, this valve is closed and the valve between the drum and suction line is opened. Frosting will occur as the ammonia distills, and after it disappears, the valve to the suction side may be closed and the oil may be drained from the bottom of the drum, ammonia-free.

Oil on hand, which is known to contain water, may be freed of contamination by filtering through fuller's earth. Newly purchased oil should be kept in sealed containers until time to add to lubricator, because mineral oil open to the atmosphere will pick up moisture.

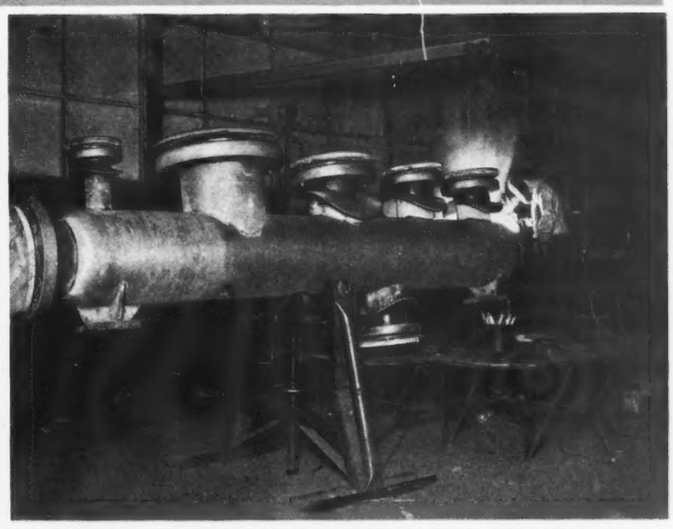
Allentown, Pa. M H WERLEY

New Equipment

(*Continued from page* 108)

Ventilating Fans

Two-, 4- and 6-blade "Dynaflow" fan units in sizes from 16-in. to 36-in. diameter have air deliveries from 1240 cfm to 26,000 cfm. Also, "Aerospot" fans of mobile and portable type in sizes from 20-in. to 36-in. diameter are effective as man coolers at distances from 50 to 175 ft. Aluminum-alloy drop-forged fan



Welding
OF PRESSURE PIPING
Is What You Make it

Perhaps no other modern process has more economic and engineering benefit to the user of pressure piping than has welding. But—users have found there is a great difference in welding. When done exactly right, it solves a host of problems otherwise difficult to deal with. When not done properly, it is extremely unsatisfactory.

The Pipe Fabrication Institute recognizes that pressure welding is what you make it—not a fool-proof process. Hence, qualified pipe fabricators conform carefully to the "welding procedure" and "qualification tests for welders," as laid down in the Code for Pressure Piping. They also appreciate the many advantages of doing as much of the welding as possible in the fabricating plant and reducing the field welding to a minimum. The layout tables, form cutting machines, work rotating fixtures, straightening tables, preheating and stress relieving equipment and testing facilities (not available in the field) of the qualified pipe fabricator offer every assurance of high quality, dimensional accuracy and economy.

THE PIPE FABRICATION INSTITUTE

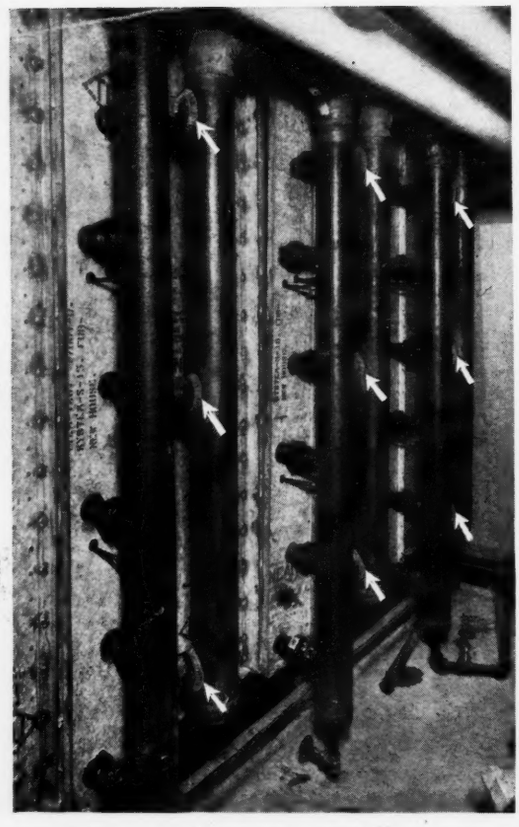
P.F.I. THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

1108 CLARK BUILDING • PITTSBURGH, PA.

The names "WeldOlets" and "ThredOlets" are Bonney trade marks registered in the United States Patent Office. Full patent coverage for designs, principles and construction has been granted in the United States and foreign countries.

For Air Conditioning



BONNEY WELDOLETS·THREDOLETS

WHEN welded piping was specified for the air conditioning system at the New House of Representatives Office Building, Washington, D. C.—the largest air conditioning contract ever awarded—Bonney WeldOlets and ThredOlets were specified for making branch pipe connections.

Engineers and contractors recognize the fact that they are correctly designed, make stronger outlets than any other method of making take-offs and are economical to buy and install.

WeldOlets and ThredOlets eliminate all cutting, threading and fitting of the main pipe. They make branch pipe connections of full pipe strength that are absolutely leak-proof. Their funnel-shaped outlets improve free flow conditions and reduce turbulence and friction to a minimum.

Your piping job may not be air-conditioning, but regardless of what it is for—whether new construction or maintenance — WeldOlets and ThredOlets will make better take-offs at less cost than any other fittings.

Standard fittings are drop-forged of steel, but they're available in Toncan Iron, Wrought Iron, Brass, Monel, Everdur, etc. to meet every piping need.

Improve your next piping job and save with these fittings. Once used, you'll standardize on them. For full information write for Bulletin WT23 or see your nearest distributor.

They are easily installed!

WeldOlets and ThredOlets are quickly and easily installed. Select the position of the outlet anywhere on the main pipe, mark center lines and tack the fitting into position.

Then weld by electric-arc or oxy-acetylene method. A leak-proof joint of full pipe strength is obtained.

On two-inch outlets or larger the button is removed after installation. A full inspection of the inside of the joint is possible when WeldOlets and ThredOlets are used.

A simple Vee weld is used for attaching the branch when WeldOlets are used. If ThredOlets are used, the branch is screwed into position.

BONNEY FORGE & TOOL WORKS, Allentown, Pa.
WELDOLETS·THREDOLETS
. . . Welded Outlets for Piping . . .
Stocked by Leading Distributors

blades, rolled-steel supports for motors.

South Bend Air Products Inc, 322 E Colfax Ave, South Bend, Ind.

150-Amp Welder

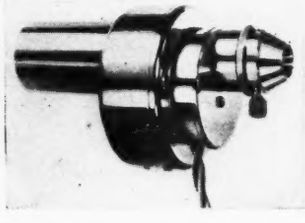
DESIGNED to occupy minimum of floor space, new welder is for lighter gage metals, both ferrous and non-ferrous. Furnished in ac drive only, machine is less than 4 ft in over-all height. Towing handle provides easy movement around

shop. Cooling and ventilating through fresh-air intake at top. and exhaust at bottom. Plug-in cable receptacles for easy current reversing, and patented single-current control.

Harnischfeger Corp, 4400 W National Ave, Milwaukee, Wis.

Radiation Pyrometer

"ARDOMETER" measures hot-surface temperatures of hot objects above 1000 F, when Ardometer is sighted so that it picks up heat rays emitted. Temperature is recorded on one of Bristol's



potentiometers—on a round- or strip-chart recorder—or is recorded on a millivoltmeter pyrometer. It can be sighted directly on object in furnace and in this position measures instantly temperature of object.

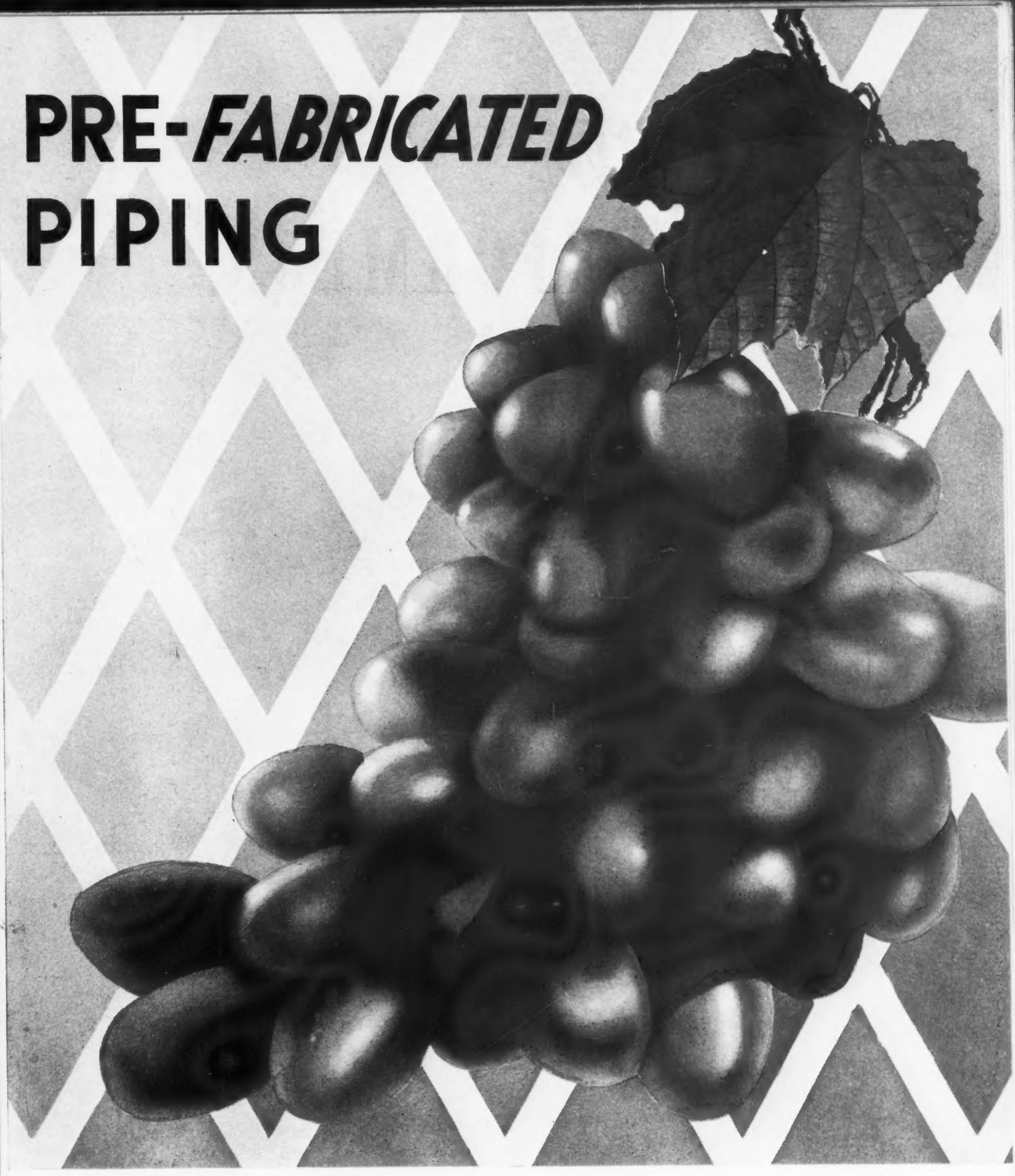
Bristol Co, Waterbury, Conn.

Furnace-Draft Control

SEQUENCE furnace-draft control is designed to prevent blowback that occurs

POWER and INDUSTRIAL PIPING FABRICATORS and CONTRACTORS

PRE-*FABRICATED* PIPING



Fits as Close as the Skin on a Grape

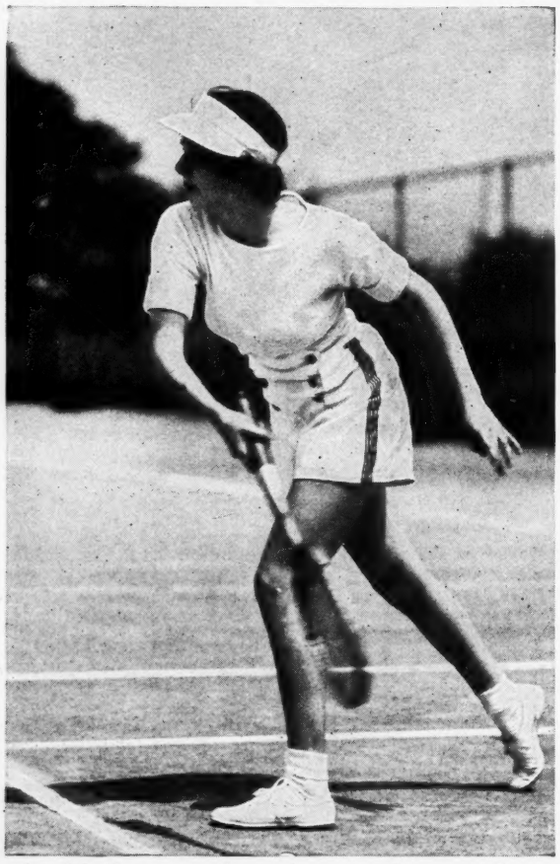
Precise adherence, E-X-A-C-T-L-Y to your specifications and dimensions is one inviolable rule of all piping work, prefabricated by us. "Nearly" and "almost" are not good enough. No matter how big, or how complicated or how many pieces are required, you can count on their fitting without "persuasion" or "coaxing" or "force". This saves time and money in erection. Ask us to send a representative or send us your prints for a quotation on your next piping job, large or small. The Benjamin F. Shaw Co., 502 E. Second St., Wilmington, Del.

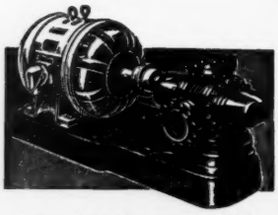
SHAWCO

Smooth PERFORMERS!

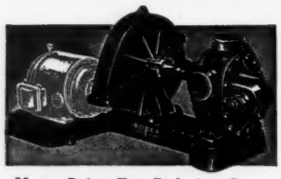
★

To be a smooth performer on the tennis court, one must have the ability to coordinate balance, rhythm, speed and power.

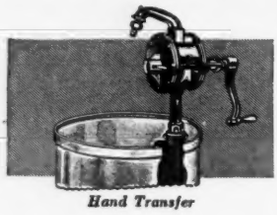




Direct Drive (no gears or belts)



Motor Drive Tru Reducing Gears



Hand Transfer

★ To be smooth performers in any plant, pumps must be endowed with the same qualifications as the expert tennis player . . . balance, rhythm, speed and power.

Roper Pumps not only have these qualities so necessary to efficient service and low upkeep, but they are also easy to install and service.

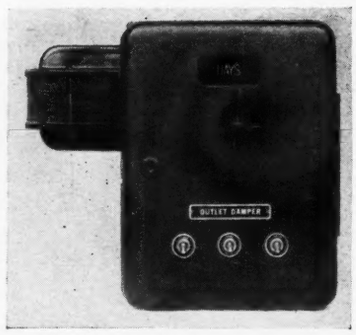
Roper Pumps are the first choice of industry because they deliver the greatest amount of service per dollar. They are 80 years beyond experiment . . . scientifically engineered and simplified to render long trouble-free service.

Write for prices and Bulletin P-1. Get the facts.

Geo. D. Roper Corporation, Rockford, Ill.

ROPER *Rotary* PUMPS

DEPENDABLE - SINCE 1857



during ignition period in on-and-off type oil and gas burners and stokers. Electrically operated control is precisely timed to open wide up-take damper an instant before burner or stoker comes on, thereby preventing build-up of pressure. Bulletin No. 105.

The Hays Corp, Michigan City, Ind.

Unit Conditioner

"UNITAIRE" self-contained unit conditioners made in two sizes with capacities of 2½ and 3¾ hp. Motor, compressor and condenser are hermetically sealed. Adjustable thermostatic control is at center of cabinet. Two switches permit maximum flexibility of operation; one

controls entire cooling mechanism, and the other blower motor only. Can be placed in any position within room to be conditioned, occupying space approximately 3 ft wide, 2 ft deep, 8 ft high.

Westinghouse Electric & Mfg Co, E Pittsburgh, Pa.

Insulating Tapes

ELECTRICAL insulating tapes, woven entirely from glass yarns, have appearance and flexibility of ordinary textiles. Intended for insulation of coils for motors, generators, transformers, etc. They impregnate readily with resins, gums, and varnishes to form an insulation impervious to moisture and of high dielectric strength.

Corning Glass Works, Fibre Products Div, Corning, N. Y.

AUTOMATICALLY MATCHED TO VARIATIONS IN LOAD

-instantly -accurately

SMOOTH machine performance depends on unvarying speed. More load demands *more power . . . automatically, smoothly, accurately!*

Westinghouse Turbine governing mechanism — the mechanical "mind" that controls the speed — gives instant speed regulation, regardless of load variations. Friction which might impede governor action and cause wear of parts is minimized. There is no soft packing on the valve stem — thus overcoming a frequent cause of sticking.

Improved speed regulation is just one of four vital points in turbine design where Westinghouse General Purpose Turbines reflect the experience of 40 years of leadership in turbine engineering. *Investigate the others*— ask or write today for Booklet 2137. Westinghouse Electric & Manufacturing Co., Dept. 7-N, East Pittsburgh, Pennsylvania.

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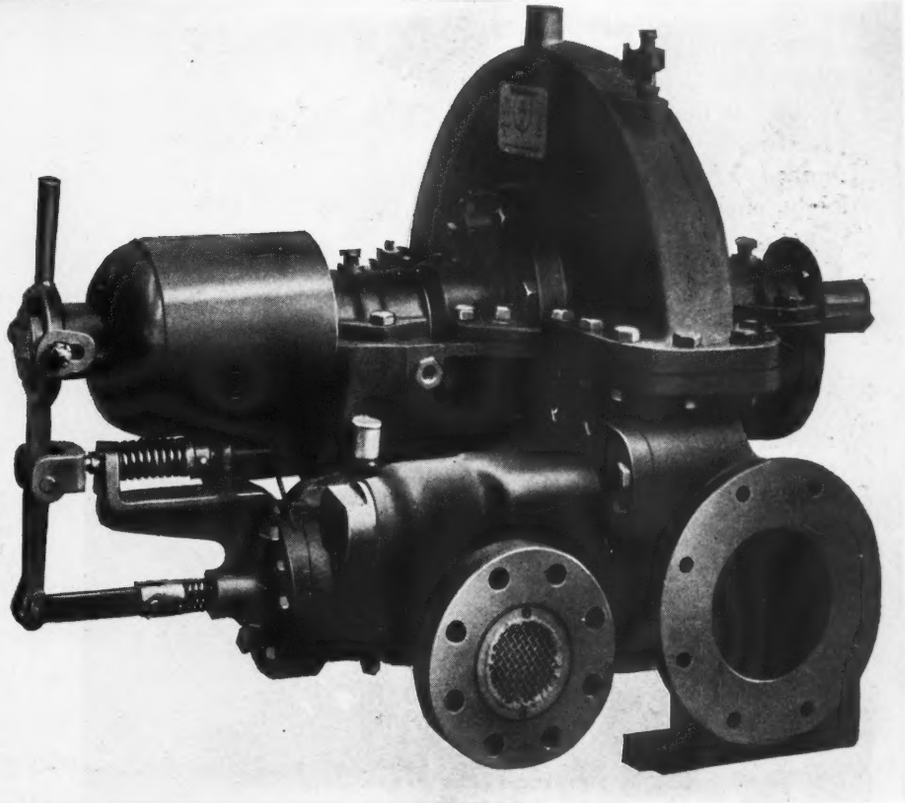
Westinghouse

GENERAL PURPOSE

STEAM TURBINES

Checked for..

- CONTINUOUS SERVICE
- CONSISTENT ECONOMY
- CLOSE SPEED REGULATION
- COMPLETE SAFETY



Westinghouse *Complete* STEAM AND STOKER SERVICE

TURBINES · CONDENSERS · FEED WATER HEATERS · VACUUM EQUIPMENT · STOKERS

They've Got Everything

Fairbanks Valves have unusual strength and long life. They are made of the highest grade materials, uniformly distributed and accurately machined throughout. Before leaving our factory every valve is carefully inspected and tested.

In every detail, Fairbanks Valves are built to withstand severe service and assure low maintenance cost.

Your satisfaction is assured by our experience of over fifty years in the manufacture of valves.

Distributors everywhere sell Fairbanks Bronze and Iron Valves for low, medium or high pressure, with screwed and flanged ends, in globe, gate, angle, check and cross patterns.

Write today for Catalog 21.

THE FAIRBANKS COMPANY
Valves, Dart Unions,
Hand Trucks and Wheelbarrows
397 Lafayette St., New York, N. Y.
Boston, Pittsburgh—
Distributors in Principal Cities
Factories: Binghamton, N. Y., Rome, Ga.

Fairbanks
Bronze and Iron **Valves**

STRAWS

(continued from page 96)

Commerce St, 30x250 ft. Cost about $150,000. Leo F Caproni, 1221 Chapel St, New Haven, architect.

FLORIDA——Gainesville contracted Albert W Smith Co, Gainesville, and Crawford & Slaten, Atlanta, Ga., for improvements in municipal power plant, including boiler and accessories. Cost about $40,000.

ILLINOIS——St. Charles will take bids soon for power plant for new 2-story city hall building. Cost over $125,000. Harold R Zook, 140 S Dearborn St, Chicago, architect.

Division of Architecture and Engineering, Springfield, has low bid from Lasker Boiler & Engineering Corp, 3201 S Lincoln St, Chicago, for boiler unit and auxiliary equipment for power house at State Training School for Girls, Geneva, Ill., at $27,915.

INDIANA——Board of Public Works, Kendallville, awards contract soon for three horizontal, centrifugal, non-clogging sewage pumps, capacity of 200-, 300- and 500-gpm, respectively, air blower and auxiliary equipment for municipal sewage plants. $90,000 has been arranged for this and sewage treatment works. Charles Hurd, Architects' & Builders' Bldg, Indianapolis, consulting engineer.

IOWA——Des Moines plans water-softening plant for municipal waterworks. Cost about $950,000. Alvord, Burdick & Howson, 20 N Wacker Dr, Chicago, consulting engineers.

Alden Co-operative Creamery, Alden, plans 1-story cold storage plant with locker system. Cost about $30,000, with equipment.

Burlington plans extensions in municipal steam-heating plant and system, including new transmission pipelines to several buildings.

KENTUCKY——Lexington Water Co, Lexington, plans steam turbines, generators, motor-driven pumping machinery, filtration apparatus, purification machinery and other equipment in connection with expansion in waterworks stations. Cost estimated at $200,000. Permission has been secured.

Mayor's Flood Relief Committee, Louisville, Roy W Burke, chairman, plans series of 7 large electric-operated pumping stations in connection with flood-relief program; also will install 37 flood gates for sewage system and other structures. Cost about $6,000,000. James B Wilson, city engineer.

State Department of Welfare, Frankfort, will soon begin construction of central power plant at new state prison buildings at La Grange, entire project to cost over $800,000. Ralph C Wyatt, Frankfort, chief engineer.

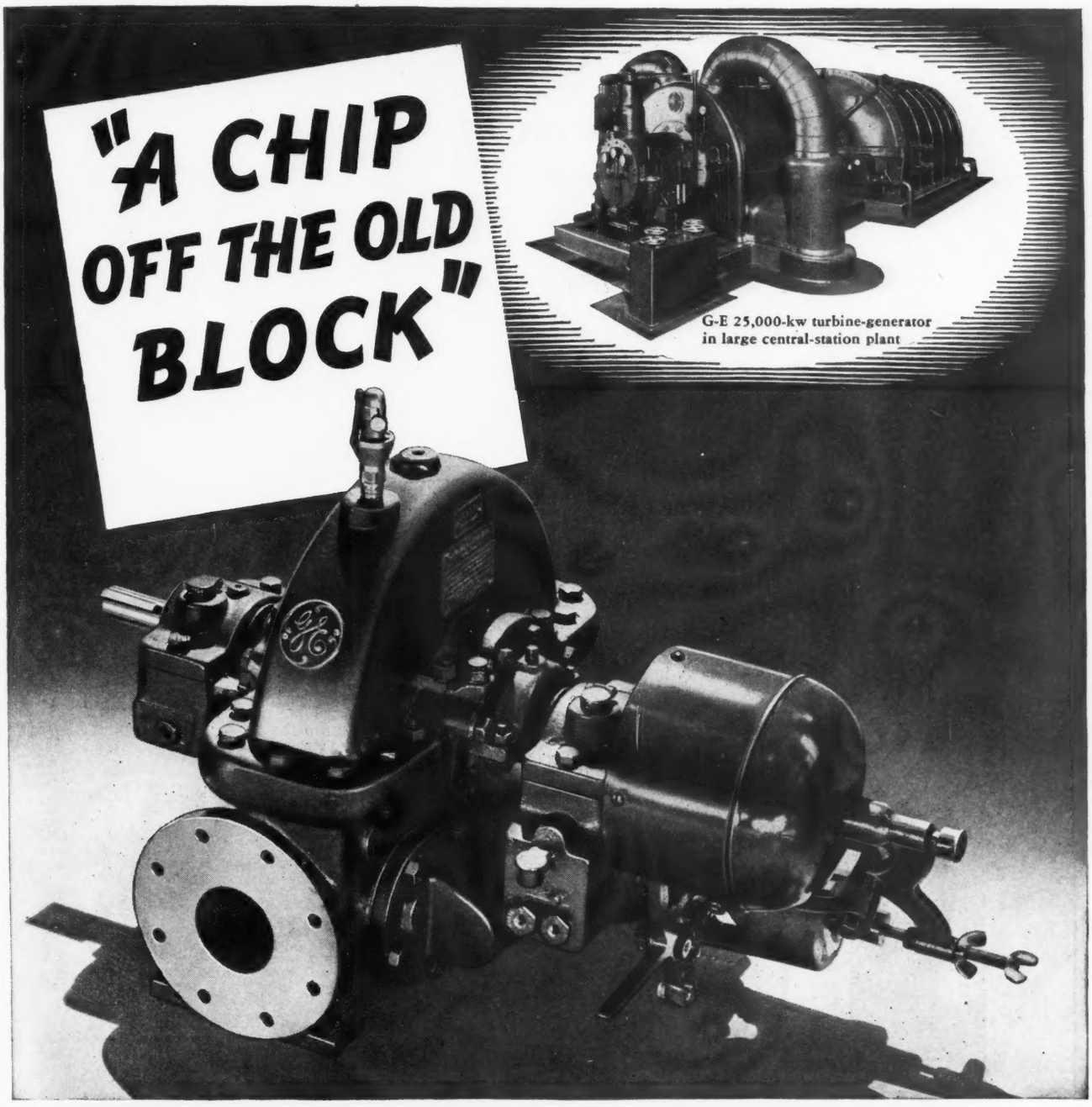
LOUISIANA——Supreme Sugar Refinery, Napoleonville, will place contracts soon for boiler units, pumps, conveyors, generator and accessories for power house at cane-sugar mill, in connection with rebuilding of plant, recently destroyed by fire. Loss about $500,000. Leo S Weil and Walter B Moses, 425 Peters St, New Orleans, engineers.

Sunset has low bid from Robert DeSelles, Cheneyville, for municipal natural-gas system, including pipelines and control station, and will make award soon. F P Joseph, Glenmore, consulting engineer.

Shreveport Charity Hospital, Shreveport, plans new ice-manufacturing and refrigerating plant at institution, for which fund of $38,000 is being arranged. Also plans new mechanical laundry, to cost $55,000 with machinery.

MARYLAND——Board of Awards, Baltimore, contracted John McShain, 6 W Madison St, Baltimore, for new mechanical-blower house at Black River sewage plant at $159,200; also let contract to Edward Bauernschmidt, 1528 N Gay St, Baltimore, for electrical equipment, same plant, at $71,300.

Crown Cork & Seal Co, Baltimore, has filed plans for extensions in boiler house at metal-cap-manufacturing plant. Lucius R White, Jr, 10 W Chase St, Baltimore, architect.



G-E SMALL TURBINES FOR MECHANICAL DRIVE

Your auxiliaries, too, need dependable power. These small turbines, like the large G-E turbine-generators, are outstanding for their reliable operation. So whenever you want to drive a boiler-feed pump, air compressor, fan, or any other auxiliary with a small turbine, remember that you can specify General Electric, the best buy in turbines, at no extra cost.

GENERAL ELECTRIC

Filing No. 5400

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For ACCURATE Measurement

SIMPLEX
VENTURI TYPE
METERS

Simplex, type MO, Meter Register

- **Economical plant operation demands the keeping of reliable flow records of all plant functions. SIMPLEX VENTURI TYPE METER REGISTERS provide an accurate, sensitive means of obtaining such records.**
- **Sturdy in design, built for wide range service, Simplex Meters are selected by the discerning engineer for boiler feed, steam, condensate or evaporate flow measurement.**
- **Simplex Meters can be furnished in any size and for operation under working pressures up to 2500 pounds.**
- **Let Simplex Engineers help you with your metering problems.**

Write for Bulletin 42-A

SIMPLEX VALVE AND METER COMPANY
6780 Upland Street **Philadelphia, Pa.**

MICHIGAN——Lansing will award contract soon for 6-story superstructure for addition to municipal light and power plant, including extensions in central steam-heating department. Cost about $2,750,000, with equipment. Work is scheduled for completion late in 1938. Claude Erickson is engineer, and Bowd & Munson, associate engineers, both Lansing.

Southeastern Michigan Electric Cooperative, Inc., Adrian, contracted Henry C Weber Construction Co, Bay City, for electric generating plant on local site, at price of $29,768, exclusive of equipment. Work is scheduled to begin at once.

Carrollton plans electric-operated pumping plant in connection with extensions in waterworks system. Cost about $150,000. Francis Engineering Co, Saginaw, consulting engineer.

Sisters of Mercy, Detroit, care of Richard H Marr, 415 Brainard St, architect, plans central-heating plant in new multistory nurses' home at Pontiac. Cost about $400,000.

Saginaw plans refrigerating plant and system in proposed municipal market building. Cost over $500,000.

MINNESOTA——Truman is considering a municipal electric plant, using diesel-generator units. Proposed to arrange fund of about $100,000 for project. E E Olson is chairman of committee in charge.

Winthrop plans improvements in municipal steam-distributing system, including new pipelines and other equipment. Rose & Harris, Essex Bldg, Minneapolis, consulting engineers.

Madison is arranging special election to vote bonds for $135,000 for extension in municipal power plant, including generator unit, water softener with capacity of 280,000 gpd. Perkins & McWayne, Paulton Block, Sioux City, Iowa, consultants.

Madelia will hold a special election soon to approve project for a municipal light and power plant, and appropriate funds for work. Estimates of cost being made.

Kelliher plans 1-story electric plant and municipal pumping station, and will proceed with work at once by WPA labor. Financing through Federal aid.

MISSOURI——Board of Public Service, St. Louis, has awarded contract to Moore Steam Turbine Co, at $60,065 for two 625-kw, steam-turbine-driven electric alternators for service building at city hospital.

MONTANA——Lewistown plans 20-in. steel pipeline from Big Spring to city limits, about 6 miles, for main water-supply line. Bond issue of $196,000 voted for this and other waterworks improvements. Joseph Schmit, city engineer.

NEBRASKA——Fremont will award contract soon for 4-story and basement addition to municipal power plant for expansion in steam division. Cost about $225,000 with new boiler units and auxiliary equipment. Financing arranged. Black & Veatch, 4706 Broadway, Kansas City, Mo., consulting engineers.

Metropolitan Utilities District, Omaha, plans extensions in pipeline system for gas distribution in a number of recently created districts in city. Col T H Leisen, secretary.

Lincoln Ice & Coal Co, 3600 48th St, Lincoln, plans rebuilding portion of ice-manufacturing plant, recently destroyed by fire. Loss reported close to $30,000.

Grand Island has authorized fund of $50,000 for purchase of new boiler units and auxiliary equipment for municipal power plant. Black & Veatch, 4706 Broadway, Kansas City, Mo., consulting engineers.

Auburn has voted to purchase local steam-electric power plant of Western Public Service Co, and will convert for municipal operation. Extensions and improvements are planned.

NEW MEXICO——Dept of Indian Affairs, Albuquerque, contracted Fairbanks, Morse & Co for engine unit and accessories at $18,927.54, for power station at Window Rock.

NEW YORK——545-567 President St Corp, Brooklyn, N. Y., has contracted Frick Co for 160-ton ice-making machine, one of the largest of its kind to be erected this season. It is expected to be in operation this month.

This Turbine Cost Over $1,000,000

Only by Keeping Solid Matter out of Steam can this Investment be Protected!

Low cost insurance . . . a fraction of a cent for every thousand dollars of your power plant investment . . . that's what Allis-Chalmers Akon Feedwater Treatment is!

It cuts your power plant maintenance to the absolute minimum by eliminating costly scale, corrosion, and carryover. It protects your power plant investment by giving longer life to tubes, turbine blades, and other power plant equipment, subject to corrosion and scale.

Akon Feedwater Treatment, unlike many other feedwater treatments, is not offered as a cure for all complaints. It is specified by Allis-Chalmers trained feedwater engineers as a supplementary treatment for use in conjunction with a softener or chemicals best suited to your particular plant's requirements.

Leading industries throughout the country are taking advantage of Allis-Chalmers 70 years of broad power plant engineering experience that stands behind Akon.

Protect your boiler plant! Follow the lead of other experienced engineers. Pennies can protect thousands of dollars of investment! Specify Allis-Chalmers Akon Feedwater Treatment—low cost insurance.

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FEED WATER TREATING DIVISION

ALLIS-CHALMERS

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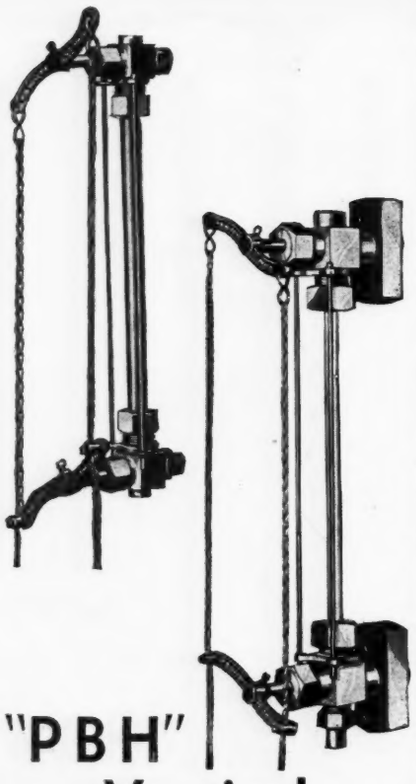

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Opened or shut by less than a quarter-turn. When a glass breaks, the gauge is shut off by a pull of the chain. No scalds; no burns. Steam and water passages are ample and have no "pockets" to collect sediment. Body is extra heavy and of best steam metal. All valve stems packed with asbestos graphite rings—nuts are large to accommodate ample size rubber washers. All Double Extra Heavy water gauges have monel metal seats and valve stem loose discs. All extra heavy water gauges have monel metal loose disc valve stem tips. All gauges can be equipped with an attachment which shuts off both water and steam automatically should the gauge glass accidentally break.

For the complete PBH line of Power Plant Equipment and instruments, write today for catalog A34.

The PAUL B. HUYETTE CO., Inc.

Est. 1896

401 N. Broad St., Philadelphia, Pa.

NORTH CAROLINA——Skyland Packing Co, Hendersonville, H G Carlisle, head, plans boiler house at new local food-canning and packing plant. Entire cost close to $50,000.

Brockwell Operating Co, 1005 Buchanan Blvd, Durham, S B Brockwell, president, plans pumping equipment, steel storage tanks, pipelines and other facilities at new oil- and gasoline-storage terminal on riverfront at Fayetteville.

Board of Trustees, Watts Hospital, Broad St, Durham, plans boiler units and auxiliary equipment in power house. Also new mechanical laundry equipment. Cost about $75,000. Syska & Hennessy, 420 Lexington Ave, New York, N. Y., consulting engineers.

White Ice Cream & Milk Co, Wilmington, plans refrigerating plant in new 1-story dairy products plant, 73x195 ft. Cost about $65,000. McCormick Co, 121 S Negley St, Pittsburgh, Pa., architect and engineer.

Gastonia Full-Fashioned Hosiery Mill, Inc, Gastonia, plans air-conditioning system in new local mill. Entire cost close to $60,000. H V Biberstein, 1600 Elizabeth Ave, Charlotte, architect and engineer.

NORTH DAKOTA——Farmers' Union Produce Assn, Hillsboro, has approved plans for cold-storage plant with locker system in connection with new local creamery. Cost about $40,000 with equipment.

OHIO——Shellmar Products Co, Mount Vernon, contracted Surface Conbustion Co, Toledo, for air-conditioning system in new addition to printed-cellophane products plant. Project will cost about $75,000.

State Board of Education, Columbus, has low bid from Downing & Hetrick Co, Columbus, at $21,200, for engine-generator unit for power house at Ohio University, Athens.

Tippecanoe City will place contracts soon for equipment for expansion in municipal power plant, including steam-turbine-driven exciter, generator air cooler, forced-draft cooling tower. Walter I Barrows, Reibold Bldg, Dayton, consulting engineer.

Stillwater Clay Products Co, Newport, plans boiler house in connection with rebuilding of 3-story sewer pipe-manufacturing plant, recently destroyed by fire. Loss over $150,000.

Board of Trustees, Antioch College, Yellow Springs, contracted General Motors Corp for 300-kw Winton diesel generator unit. Cost about $50,000.

OKLAHOMA——Fairview has voted bonds for $60,000 for extensions in municipal light and power plant, including 700-hp diesel-generator unit and auxiliary equipment, for which awards will be made soon. E A Evans, engineer.

S O White and associates, Clinton, plan steel pipeline system for natural-gas distribution at Geary. Franchise has been granted. Cost about $45,000.

Enid Citizens' Municipal Gas Committee, Enid, N E Grove, chairman, is considering bond issue of $700,000 for purchase of existing gas-distributing system, to be extended and improved with new pipelines and operating facilities.

Oklahoma Pipe Line Co, Tulsa, has authorized 8-in. welded-steel pipeline from Springer to Sulphur, about 21 miles, for crude-oil transmission. Booster stations will be installed. Cost over $150,000.

Continental Oil Co, Ponca City, plans compressors, pumping machinery, steel storage tanks and other equipment in new casinghead-gasoline plant in K-M-A oil field district, Wichita County, Tex. Welded-steel pipeline will be built for gas transmission to plant, with booster station. Cost over $200,000.

OREGON——Terminal Ice & Cold Storage Co, Salem, plans new 1-story cold-storage and refrigerating plant on local site at 245 D St. Cost about $45,000.

Portex Oil Co, Portland, plans compressors, pumping machinery, boiler-house equipment at new natural-gasoline plant near Logansport, La. A welded-steel pipeline will be built for natural-gas transmission to plant. Cost about $150,000.

Ochoco Lumber Co, Prineville, plans boiler house at new lumber and woodworking mill on John Day Highway. Cost about $100,000. F Hill Hunter, engineer.

SOUTH CAROLINA——Greenwood County Finance Board, Greenwood, contracted W

AMBEST
METALLIC PACKING

AMBEST in Ring form — available in any size.

SPARE the PACKING and SPOIL THE ROD *or* TRY AMBEST

AMBEST in loose Strand form—to suit any size rod or box.

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AMBEST is good to the last stroke of any good rod — the universal packing for all conditions of pressures and temperatures up to 600 degrees. Get longer service out of good rods by using AMBEST on engines, pumps, compressors, (both ends) throttle and valve stems, condenser tubes, etc.

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A Genuine Briar Root Pipe Sent Free with an order for Five Pound can.

For a limited period of time we will send you — ABSOLUTELY FREE — a cool smoking, BRIAR PIPE with every order for a five pound can of AMBEST. Use coupon below in accepting this offer.

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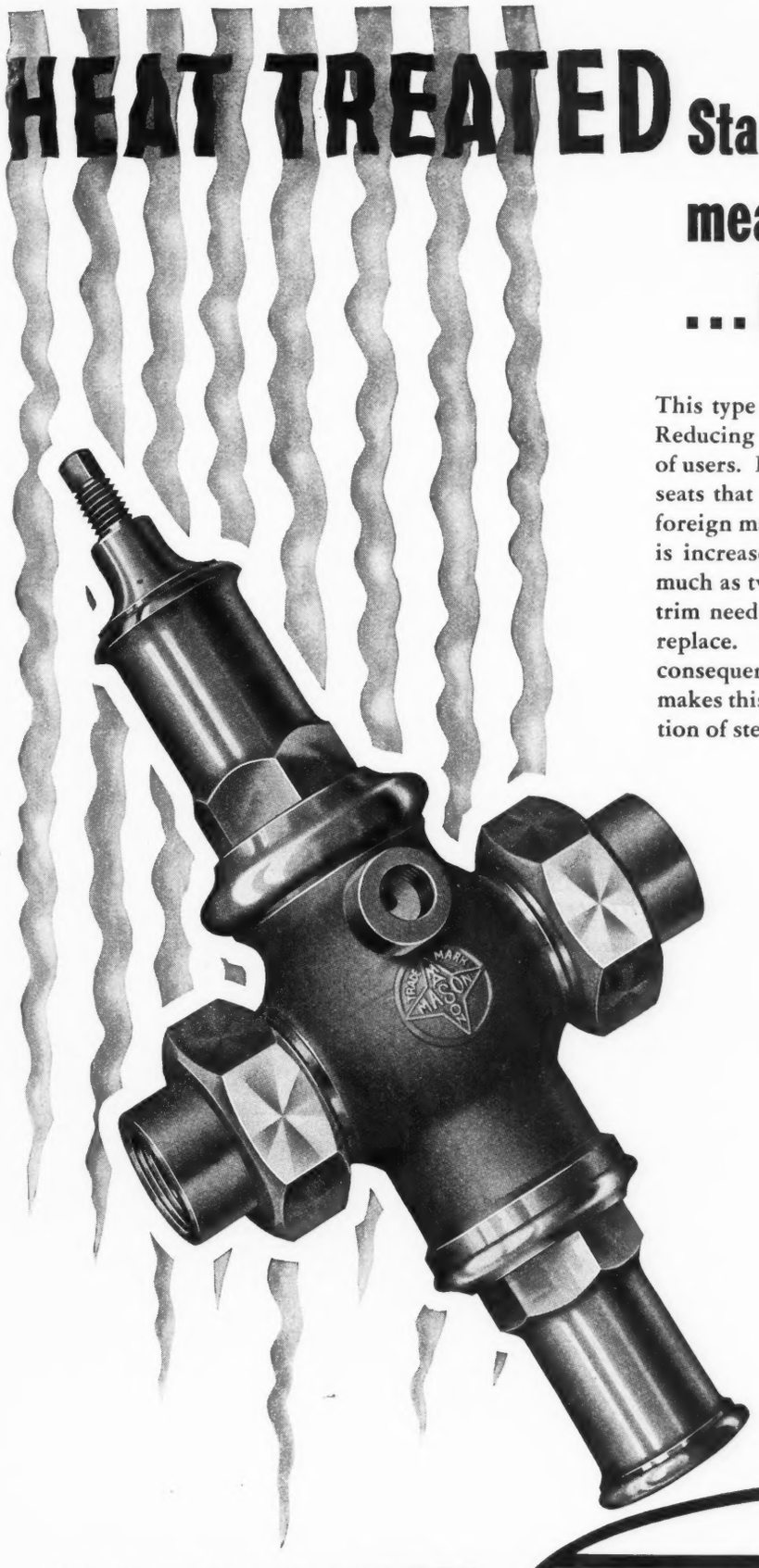
HEAT TREATED Stainless steel trim means longer life ... less maintenance



This type of trim, standard in Masoneilan No. 11 Reducing Valves, has meant savings to thousands of users. For heat treating so hardens the valve and seats that erosion, steam cutting and damage from foreign matter are minimized — the life of the valve is increased and maintenance expense reduced as much as two-thirds. If, after extra long service, the trim needs renewing, it is inexpensive and easy to replace. The trend to higher boiler pressures and consequent increased necessity for reducing valves makes this economy a large factor in efficient operation of steam service.

OTHER FEATURES THAT MEAN BETTER CONTROL

- Wide range of adjustment without change of spring.
- Unaffected by fluctuating initial pressures.
- Extremely sensitive and accurate.
- Downstream connection increases capacity of valve and accuracy of control.
- Extremely sensitive and accurate.
- Has tight shut-off.

SPECIFICATIONS

Bronze (sizes ½" to 2") with union connections — M.W.P. 250 lbs.

Iron (sizes 2½" to 4") with extra heavy flanges — M.W.P. 250 lbs.

Steel (½" to 4") with Series 30, 40 or 60 Flanges.

Reduced pressure ranges 5 to 100 lbs; 100 to 225 lbs; 100 to 300 lbs. (steel).

If your problem is finding a long lasting valve for reducing steam pressures, investigate the Mason-Neilan line. Ask your mill supply distributor for Mason-Neilan Catalog No. 63 — or communicate with our nearest office.

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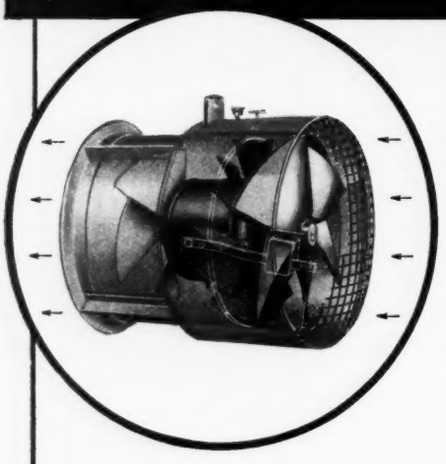


Already many of the New 2-stage Axial Flow (Wing Type COM) Forced Draft Blowers are serving Boiler Plants throughout the United States and elsewhere.

Extraordinarily Compact Highly *Efficient*.

Everything is within the Casing.

Two Axial Flow Fan Wheels—*double staged.*
A constant speed electric motor.
Built-in damper and air redirecting vanes.
Ready access to all parts.

Capacity regulation over a wide range with decreasing horsepower is obtained by adjustment of the built-in vanes, either manual or automatic.

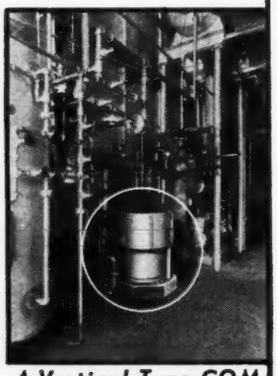
WING type COM Blowers are built for horizontal, vertical or inclined operation. They fit even the tightest spots.

Installation cost is negligible and operating cost a minimum.

Static pressures as high as 8"—volumes as great as 50,000 CFM.

If you need forced draft, the WING Type COM Blower will provide it at low first cost, low running cost and with quiet operation.

Write for descriptive catalog CO-1



A Vertical Type COM Blower serving a stoker-fired boiler through duct under floor.

L. J. WING MFG. CO.
WEST 14TH STREET AND 7TH AVE.
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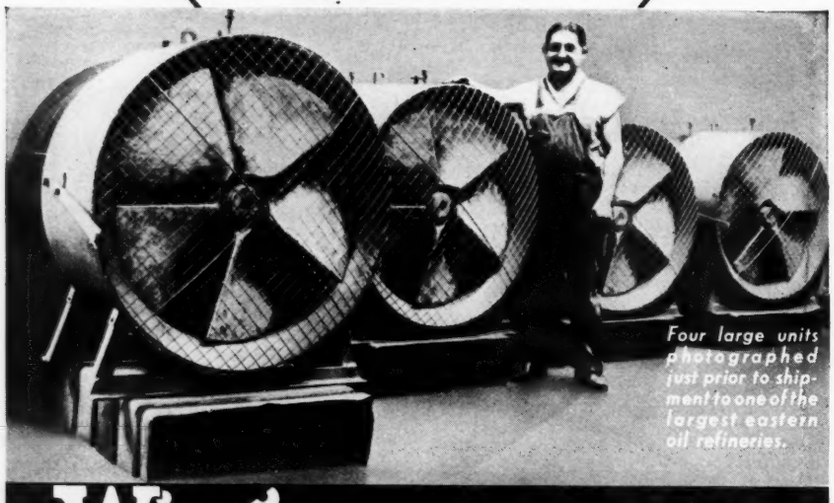

Four large units photographed just prior to shipment to one of the largest eastern oil refineries.

Wing Type COM
Compound Motorized BLOWERS
FOR STOKER • OIL • GAS • and PULVERIZED FUEL FIRED UNITS

E Grannis, Fayetteville, and Lee Construction Co, Charlotte, at $509,689, for construction of power dam, power house and spillway at Buzzard Roost, Saluda River, for new county-owned hydroelectric plant. Equipment awards are being made separately. Entire project will cost $2,800,000. Financing through Federal aid. D T Duncan is engineer.

SOUTH DAKOTA——Construction Service, Veterans' Administration, asks bids until June 7 for boiler unit and fuel-burning equipment for power house at institution at Hot Springs.

Sioux Falls will soon award contract for new engine-generator unit and auxiliary equipment for municipal power plant.

Salem is considering municipal light and power plant. Surveys and estimates of cost will be made. Commercial Club is at head of project.

Flandreau has acquired local power plant of Union Public Service Co, and will convert for municipal operation. Plans under way for extensions, including two 375-hp diesel-generator units and accessory equipment.

TENNESSEE——TVA, Knoxville, is scheduled to secure appropriation of $2,613,000 for initial work on proposed new dam and hydroelectric station at Gilbertsville, Ky.

TEXAS——Liberty plans municipal power station, to include three 125-hp engine-generator units and auxiliary equipment. $114,000 has been arranged for this and distributing system. Garrett Engineering Co, 308 Hughes St, Houston, consulting engineer.

Electra contracted National Supply Co for three 350-hp diesel units, and Westinghouse Electric & Mfg Co for three generators and accessories, for new municipal light and power plant.

N E Mikel and D R Porter, Mesquite, head committee authorized to secure estimates of cost and arrange for erection of new municipal ice-manufacturing and cold-storage plant. Proposed to begin work soon.

VIRGINIA——Board of Education, Norfolk, plans central-heating plant in new Ocean View school, for which work is scheduled to begin soon. Cost over $275,000. Ferguson, Meakin & Moore, New Monroe Bldg, Norfolk, architects.

Bureau of Yards and Docks, Navy Department, contracted Permutit Co for water-treatment plant at naval operating base, Norfolk, at $14,321.

Bureau of Yards and Docks contracted A Wilson & Co at $152,870 for two water-tube boilers, piping, wiring and accessories in power house at marine barracks, Quantico, including removal of two existing old boiler units.

WASHINGTON——Ellensburg will place contracts soon for diesel-generator unit and auxiliary equipment for municipal power station. R P Ryker, Ellensburg, Kittitas County engineer, in charge.

Shelton Meat & Ice Co, Shelton, plans refrigerating plant and system in new 1-story addition, for which work will begin soon. Cost close to $30,000, with equipment. Arthur Barton, engineer.

State Dept of Finance, Budget and Business, Olympia, will award contract soon for turbine-generators and accessories, switchboard and miscellaneous equipment in power house at Northern State Hospital, Sedro-Woolley.

WISCONSIN——Superior plans municipal ice-manufacturing and cold-storage plant. Cost about $100,000, with equipment. Financing through Federal aid.

Northern Paper Mills, Inc, Green Bay, contracted Baker Construction Co, Green Bay, for superstructure for new steam-electric generating plant at mill, on which work will begin at once. Cost about $750,000, with equipment. Completion is scheduled by close of year. Sargent & Lundy, Inc, Chicago, consulting engineer.

Wisconsin Refrigerated Lockers, Inc, Bloomer, plans new 1-story cold-storage plant on local site, with locker system. Cost close to $30,000, with equipment.

WYOMING——Lower Valley Light & Power Co, Afton, contracted C A Nickerson Machinery Co, Salt Lake City, Utah, for Leffel-type waterwheel and electric generator, with auxiliary equipment for hydroelectric station.

CONSIDER THE "BEFORE" AND "AFTER"

OF *Chapman* POWER PLANT VALVES

High Pressure Steam Valve with Welding Ends, Equipped with Chapman Motor Units

There are two sides to the story of Chapman Power Plant Valves. Our side—a story of putting more into them. Your side—a matter of getting more out of them.

The raw materials we use, for instance, must be well qualified for this work. And our special steels are poured in our foundry—with metallurgical control of each melt. Moreover, parts are machined to exacting standards of precision. And every valve is subjected to a rigid routine of tests before it goes to you.

That is why Chapman Valves stay with you longer *after* they go to work—even with temperatures up to 1000° F and pressures of 1500 lbs. That is why you find so many Chapman gate, globe, check, and angle valves—with all types of operating mechanisms—in power plant service today.

Write for more information.

CHAPMAN STEEL VALVES ARE MADE IN THESE ALLOYS

Carbon Steel.
Carbon Molybdenum Steel.
Chrome Nickel Steel.
Nickel Steel.
Chrome Molybdenum Steel.
Chrome Tungsten Steel.
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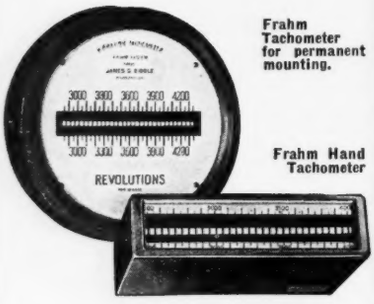
The **CHAPMAN VALVE**
MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

INSTRUMENTS *for* MEASURING SPEED



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"FRAHM" TACHOMETERS

measure r.p.m. as well as rates of vibration, merely by being mounted on or held against the machine under test; they require no belts, gears or electrical connections. Speeds up to 30,000 r.p.m. or v.p.m. Widely used on steam turbines and centrifugal pumps. Hold original calibration during years of continuous service. Write for descriptive *Bulletin 1510-P.*

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measures average r.p.m. or feet per minute without any calculations. Simply insert tip and press button. Automatic, accurate and reliable. Reads up to 20,000 r.p.m. and 10,000 feet per minute. Described in *Bulletin 1505-P.*

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measure rotating speeds directly in r.p.m. and linear and peripheral speeds in feet per minute. Also show speed variations. Accurate, dead beat and dependable. Ranges up to 40,000 r.p.m.

Write for *Bulletin 1505-P* which describes these as well as other types of speed-measuring instruments.

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ELECTRICAL INSTRUMENTS

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Engineers' Books

(Continued from page 94)

The work is divided into six parts: definitions and general purpose provisions; types of wiring approved under given conditions; installation of materials and apparatus; general requirements for wiring installations; special cases, such as outside wiring, hazardous locations, circuits and equipment operating at over 600 volts, etc; and construction of materials, devices, fittings and equipment.

Illustrations have been used lavishly to show Code applications under a wide range of conditions. 39 tables most frequently used by inspectors, contractors and engineers are arranged together in the last chapter. For those interested in light and power wiring, this handbook provides a practical guide.

Air Conditioning

HEATING, VENTILATING AND AIR CONDITIONING FUNDAMENTALS (1937)—*By William H Severns, professor of mechanical engineering, University of Illinois. Published by John Wiley & Sons, Inc, 440 4th Ave, New York. N. Y. 450 pages, illustrated, 6x9¼. Price $4.00.*

Although principally a college textbook, there is much material of value to both consulting and operating engineers. Chapter subjects include: several on heating (boilers, piping, fuels, load calculations, etc.); air conveying and cleaning; ventilation; air humidification dehumidification and drying of materials; controls; and summer cooling of buildings.

The last chapter will be widely useful to air-conditioning engineers as it discusses loads, commercial equipment, and methods.

Chemical Engineering

PRINCIPLES OF CHEMICAL ENGINEERING (1937—Third Edition revised and rewritten)—*By William H Walker, Warren K Lewis, William H. McAdams, and Edwin R Gilliland, professors of Chemical Engineering, Massachusetts Institute of Technology. Published by McGraw-Hill Book Co, 330 West 42nd St, New York, N. Y. 749 pages, 6x9 in., price $5.50.*

Earlier editions of this book have been standard references in the chemical engineering field for many years. Because of the excellence of the sections on flow of fluids and flow of heat, and on humidity and air conditioning, it has also demonstrated its value to the mechanical engineer. The comprehensive discussion of methods and machinery for processing should appeal to the power engineer, who is frequently called on to install, supply power services to, and maintain, process equipment. While not elementary the treatment is straightforward and authoritative.

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Unique Yarway Involute design.

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Unobstructed flow gives minimum loss of head.

Finely divided spray cone provides rapid cooling.

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Installations total more than 5 million gallons per minute in water cooling and air conditioning service.

Made in both cast and bar-stock types. All sizes from ¼ in. to 2½ in. Write for Catalog N-615.

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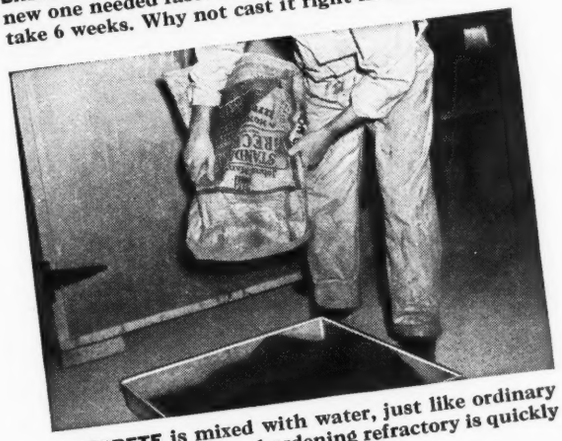
Cast them in your own plant ...quickly and at low cost ...with J-M Firecrete

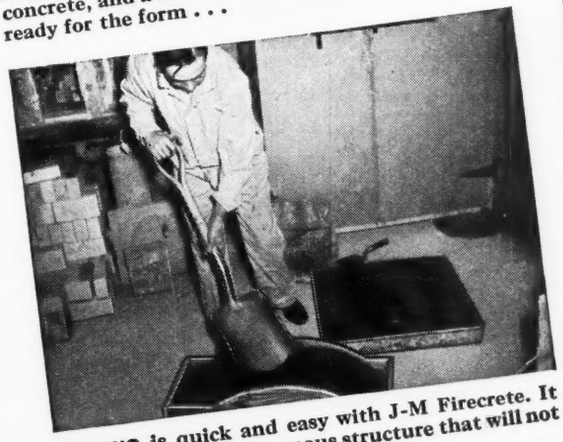
BREAKDOWN of baffle arch in small furnace . . . new one needed fast! Ordering a special shape may take 6 weeks. Why not cast it right in the plant?

WHEN you need a special shape in a hurry, think of the time and trouble you can save with J-M Firecrete. This hydraulic-setting refractory can be used to make any shape right in your own plant. It handles like ordinary concrete, hardens rapidly, has no drying shrinkage and negligible firing shrinkage, and is highly resistant to spalling. In short, it provides the means of obtaining a dependable refractory shape . . . quickly and at a low cost.

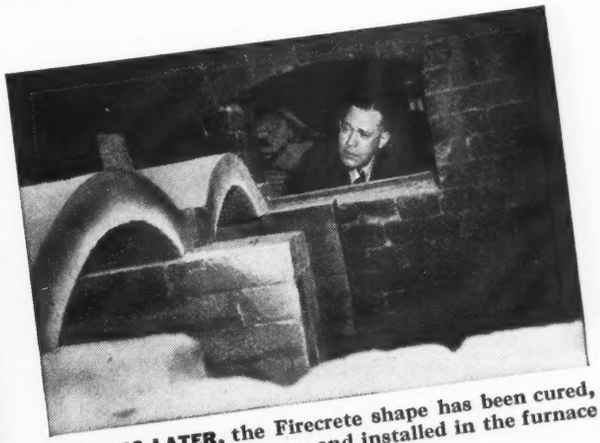
J-M Firecrete is also an excellent refractory for door linings, flues, pipes, etc. It is available in three types: Standard Firecrete (2400° F.); H. T. Firecrete (2800° F.); and L. W. Firecrete (2400° F.), the latter similar to other types but lighter in weight and lower in thermal conductivity and heat-storage capacity. For complete information on Firecrete, Hellite, No. 31 and other Refractories in the J-M line, write for Engineering Brochure DS-700. Johns-Manville, 22 East 40th St., New York City.



FIRECRETE is mixed with water, just like ordinary concrete, and a fast-hardening refractory is quickly ready for the form . . .



CASTING is quick and easy with J-M Firecrete. It forms a dense, homogeneous structure that will not shrink as it dries out . . .



22 HOURS LATER, the Firecrete shape has been cured, is removed from the form and installed in the furnace ready for use. Weeks of waiting saved!

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THE illustrations above show how Beco-Turner baffles are inclined in connection with a typical horizontal water tube boiler. In any type of boiler, Beco-Turner baffles can be installed at any angle necessary to conform to the diminishing volume of the gases as their heat is given off to the tubes.

Beco-Turner design brings practically 100% of the entire tube surface into contact with the hot gases. The result is increased efficiency and capacity—*more* steam from *less* fuel.

If you contemplate new boilers or new fuel-burning equipment, we will gladly quote on Beco-Turner baffles. We specialize in the modernization of existing boilers and will be glad to submit any possible recommendations for improving the operation of present boilers through more advanced baffle and furnace design. Send coupon for valuable catalog.

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Send blueprints for baffle recommendations.

Power Lines

(*Continued from page* 95)

A large percentage of the space on three floors of Grand Central Palace has been engaged by manufacturers who have exhibited at previous Power Shows. If expositions of the past year in other fields at all indicate a trend, a munificence of operating demonstrations and dynamic, colorful displays will feature this year's presentation of power. Likewise, an attendance exceeding 40,000 is indicated.

The Exposition, as in all of its twelve earlier appearances, will be managed by the International Exposition Co under the personal direction of Charles F Roth, president.

NAPE Honors Downeys

On May 7, W W Downey, Director of Engineering, New York Hospital and Cornell Medical Center Assn, N. Y., and Mrs Downey, were given a testimonial dinner by the Metropolitan District Committee of the NAPE. More than 150 friends attended the dinner and dance at the Riverside Plaza Hotel. Mr Downey, a member of New York No. 1 and honorary member of No. 44, is a National Trustee. Mrs Downey is National President of the Ladies Auxiliary. George Griffel presided. Speakers included Past National Presidents Fred Felderman and Horace Wilds, also Dr A A Adler and Mr and Mrs Downey, who received a grandfather clock as a permanent reminder of the occasion.

ASME St. Louis Meeting

A program of varied interest has been arranged for the ASME semi-annual meeting, being held this year in St. Louis, June 20–24. In addition to technical papers and several entertainment features, the committee has arranged trips to many plants, including Anheuser Busch, Busch-Sulzer, Cahokia power plant of the Union Electric Co, Fisher Body plant, Midwest Piping & Supply Co, and the Laclede Gas Light Co.

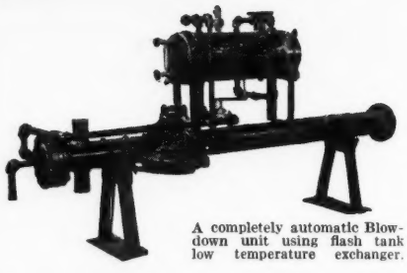
An attempt has been made to choose plants in which there is some special attraction, as, for instance, five new boiler units and two new generators at Cahokia, the unusual pipe-bending equipment at Midwest Piping & Supply, and the power-plant equipment at the world's largest brewery.

A report of this meeting will appear in August *Power*.

Oil & Gas Power Meeting in Dallas

The ASME Oil & Gas Power Conference will be held June 6–9 at the Hotel Baker, Dallas, Tex. The technical program will include papers and reports on diesel streamline trains, latest fuel-oil specifications, operating results on 2-cycle gas-fired diesels, modern practice in hydraulic governing, latest informa-

Control of Boiler Water Concentration



A completely automatic Blowdown unit using flash tank low temperature exchanger.

Save the B. T. U.'s as well as the Boiler!

The Henszey Continuous Blowdown System holds the concentration of the Boiler water at a predetermined proper degree—eliminating priming, foaming and sludge. With simple chemical treatment it prevents scale—thereby adding years of efficient life to all boiler equipment.

And you can save the B.T.U.'s as well as the boiler, because this system allows continuous, automatic Blowdown *without heat loss!*

Write in for full detailed information about this remarkable system. Do it now, because, today more than ever before, efficient and economical boiler operation is essential or profits are lost.

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BOILER WATER CONCENTRATION CONTROL SYSTEMS

MIND over METAL

FOR several years Scovill deliberated over one process of making condenser tubes before being entirely satisfied with it . . . entirely certain every step could be checked from start to finish. That process was *extrusion* and followed *hot piercing* and *cup drawing*. All three methods (as Scovill fashions them) are as closely controlled as modern science and human ingenuity can make them. For example, each heat is analyzed for composition – accuracy of temperature control is maintained throughout operations — frequent inspections are made during the process — and a final check makes certain that material meets specifications.

We like to call that — engineering in production. This is supported by years of field experience. Broadly expressed in our Heat Exchange Tube Manual are conclusions formed from these years of experience . . . information collected, for the major part, from engineers like yourself. Armed with this manual of *many* minds, Scovill representatives work with you to get results.

Not only on immediate problems is the Heat Exchange Tube Manual used; its 149 weighty pages are also at the disposal of Scovill customers and prospects.

Yes, we sell condenser tubes in eleven different alloys, but in addition, we provide Engineering data, Engineering production, and an Engineering service to each Scovill customer.

On request we will send an illustrated booklet describing the three methods by which Scovill makes condenser tubes. Address Scovill Manufacturing Company, 13 Mill Street, Waterbury, Connecticut.

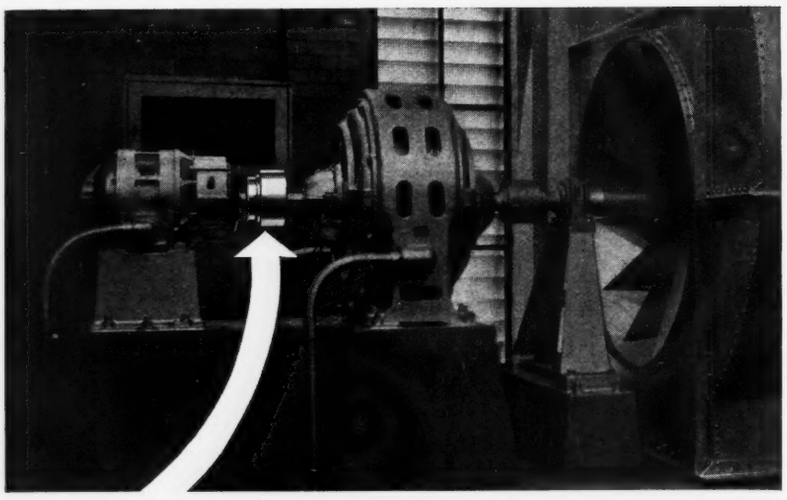
In an industrial power plant evaporator rapid corrosion occurred on the outside of the tubes near the tube sheet. The operator considered the purchase of a more expensive tube material to resist this corrosion, but having been supplied with operating data and specimen tube failures, Scovill engineers suggested a change in installation method which made the purchase of more expensive tubes unnecessary.

SCOVILL
Masters of Metal

Scovill Condenser Tubes

one product . . . three services

HILLIARD OVER-RUNNING CLUTCHES



For the LINCOLN TUNNEL

To drive 14 ventilating fans at 2 speeds the Port of New York Authority relies on Hilliard Over-Running Clutches because of their positive and automatic control. The drive can be changed back and forth at will between the low speed and high speed motors from a distant point simply by operating the motor switches.

Since clutches engage and release automatically the presence of an operator at the fans is unnecessary. . . . Get the facts on this highly dependable device and check its advantages as a Two-Speed or Stand-by Drive or as a Ratchet or Backstop. Bulletin B gives the whole story — Write for it today.

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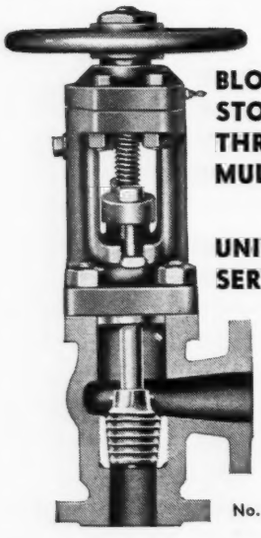

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No. 601

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tion on vibration insulation, diesel maintenance, etc.

Chesapeake-Camp Piping

The article "Partners in Power," May *Power*, page 50, inadvertently failed to name the piping contractor for the new $3,000,000 kraft-paper project of the Chesapeake Camp Corp, Franklin, Va. The complete piping system for steam, stock, water, liquor, etc, was fabricated and erected by Pittsburgh Piping and Equipment Co.

New Bridgeport Brass Mill

With its new rolling mill, representing an approximate investment of $4,000,000, rapidly nearing completion, Bridgeport Brass Co, one of America's largest independent brass-mill-products manufacturers, is making ready for increased production.

The new mill at Bridgeport, Conn., scheduled for operation in mid-summer, covers a floor area of about 200,000 square feet and will be devoted to the production in sheet form of practically all the copper base alloys. More than 1,375 tons of structural steel, a total of more than 400,000 bricks, over 28,000 lights of glass with a sash area of 50,400 sq ft, materials for 166,000 square feet of roof area were utilized in construction.

Meetings

Annual Economics Conference — *Sponsored by Stevens Institute of Technology and Society for Advancement of Management, June 24–July 2, Johnsonburg, N. J.*

American Institute of Electrical Engineers —*Summer Convention, June 20–24, Washington, D. C. H H Henline, secretary, 33 W 39 St, New York, N. Y.*

American Society for Testing Materials —*41st Annual Meeting, June 27–July 1, Chalfonte-Haddon Hall, Atlantic City, N. J. R E Hess, assistant secretary, 260 S Broad St, Philadelphia, Pa.*

American Society of Mechanical Engineers —*Semi-Annual Meeting, June 20–24, St. Louis, Mo. C E Davies, secretary, 29 W 39th St, New York, N. Y.*

ASME Oil & Gas Power Conference— *June 6–9, Hotel Baker, Dallas, Texas, C E Davies, secretary, 29 W 39th St, New York, N. Y.*

American Welding Society —*Annual meeting (in conjunction with Metals Congress Exposition), October 17–21, Detroit, Mich. M M Kelly, secretary, 33 W 39th St, New York, N. Y.*

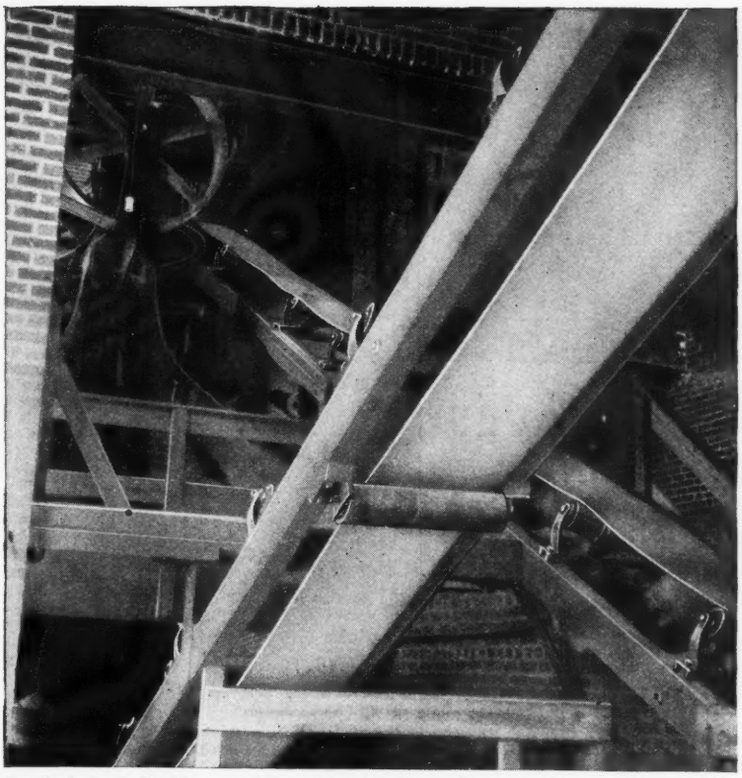
Edison Electrical Institute — *Annual Meeting, June 7–9, Atlantic City Auditorium, Atlantic City, N. J. M B Woods, secretary, 420 Lexington Ave, New York, N. Y.*

Dominion Association of Power Engineers —*1938 Convention, July 8–9, King Edward Hotel, Toronto, Ont. William J Longeway, secretary-treasurer, 130 Dunn Ave, Toronto.*

National District Heating Assn — *Annual convention, June 28–July 1, Lord Baltimore Hotel, Baltimore, Md. W H Sanford, secretary-treasurer, 1317 Spruce St, Philadelphia, Pa.*

Technical Association of the Pulp and Paper Industry—*1938 Fall Meeting, Sept. 8–10, Northland Hotel, Green Bay, Wis. R G MacDonald, secretary, 122 E 42nd St, New York, N. Y.*

Universal Craftsmen Council of Engineers —*35th International Convention and Great Lakes Power Show & Mechanical Exposition, Aug. 2–6, Hotel Hollenden, Cleveland, Ohio. E H Smith, chairman 6523 Euclid Ave, Cleveland.*



Two Manhattan Inclined Conveyor Belts carrying shale from and to pans and screens in large, recently modernized Pennsylvania brick plant. Belts shown are 240 feet and 255 feet long, 20", 4-ply International with 1/8" cover on both sides. In all, 1584 feet of Manhattan Conveyor Belting was installed.

"Figured in" on Modernization Plans

MANHATTAN CONVEYOR BELTS . . .

ANOTHER brick plant modernizes . . . and, like many others, includes Manhattan Conveyor Belts in its modernization plans. This plant, too, will find that Manhattan Conveyor Belts will set new standards for efficiency and economy.

45 years' experience in building conveyor belts to handle all kinds of materials on short or long hauls, high or low lifts, enables Manhattan engineers to build the right belt for your job.

In planning to modernize, figure on increasing your tonnage and reducing your handling costs with Manhattan Conveyor Belts. You'll find that they last and last . . . making enviable tonnage records under punishing service.

Condor PRODUCTS

Conveyor Belt	Oil and Gasoline Hose	Launder Lining
Transmission Belt	Sand Blast Hose	Industrial Brake Lining
V-Belt	Steam Hose	Molded Rubber Goods
Air Hose	Suction Hose	Rubber Lined Tanks
Contractors Hose	Water Hose	Rubber Covered Rolls
Fire Hose	Chute Lining	Abrasive Wheels—Rubber Bonded
Hydraulic Hose		

Two large Condor Conveyor Belts for carrying stone on large construction project.

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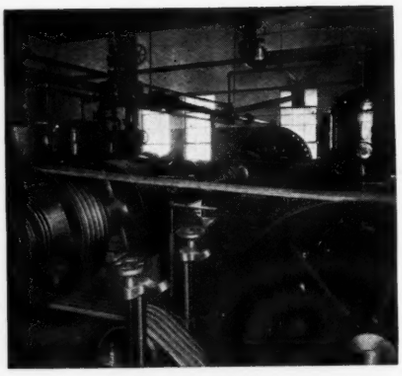

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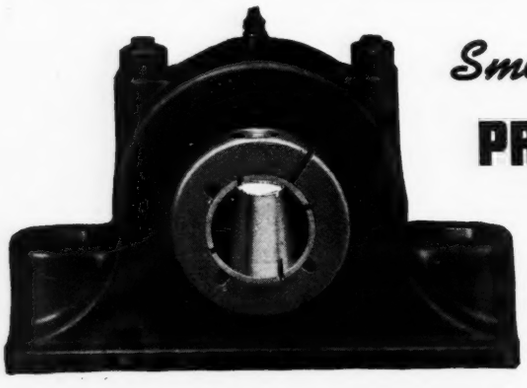

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MEDART

OBITUARIES

CHARLES H SHAW, 40, for the past three years Philadelphia office manager for Worthington Pump & Machinery Corp, died at his home on April 15. Associated with Worthington since 1920, Mr Shaw was manager of its Pittsburgh office from 1928 to 1935.

JOHN HOWALD, 60, for the past 20 years a steam engineer employed at Lasell Junior College, Auburndale, Mass., died recently from a heart attack.

HARRY A WEST, sales engineer for Walworth Co, Boston, Mass. for the past 50 years, and widely known in the valve and steam-fittings field, died at a Boston hospital on April 12.

JOHN C CAMPBELL, 78, president of Newark Wire Cloth Co, died March 20 at his home in Newark, N. J., after a short illness.

JOSEPH B FOWLER, 49, special field engineer for Cochrane Corp, died suddenly of a heart attack on April 15. Mr. Fowler, during his association with Cochrane Corp for the past 25 years, was responsible for many major developments and design improvements in the field of feedwater conditioning, deaeration and steam purification.

SIDNEY JAMES HALLS, 58, manager of the light and power department of the British Electric Railway Co, Victoria, B. C., died suddenly on April 8.

J E WRAY, manager of Allis-Chalmers district office at Philadelphia, died suddenly on April 18 as the result of a stroke.

SILAS A TUCKER, manager of Manhattan Rubber Mfg Div's Chicago branch, died April 14 at the Presbyterian hospital in Evanston, Ill.

PERSONALS

EDMUND C STONE has been appointed vice-president and general manager of Duquesne Light Co. Mr. Stone joined Duquesne in 1911, and was successively engineer of cable operations, system operator, assistant to general manager, planning engineer, and system-development manager. He was appointed assistant to the president in 1931.

H S STROUSE was recently named vice-president of Harnischfeger Corp. Mr Strouse has been estimating engineer, advertising manager, and, recently, treasurer of the corporation.

WILLIAM KRICKBAUM, president of Foster Engineering Co, Newark, N. J., was elected chairman of the board of directors. He was succeeded in the presidency by F Reid.

JOHN W ANDERSON, formerly chief engineer for De La Vergne Engine Co, and since then consulting engineer, is now manager of the engineering department, Diesel Div, American Locomotive Co, Auburn, N. Y.